Lake Ozette Sockeye

Hatchery and Genetic Management Plan

BIOLOGICAL ASSESSMENT
Section 7 Consultation

Prepared by Makah Fisheries Management for
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GLOSSARY

DNA	Deoxyribonucleic Acid
ESA	Endangered Species Act
ESU	Evolutionary Significant Unit
HGMP	Hatchery and Genetic Management Plan
HSRG	Hatchery Scientific Review Group
MFM	Makah Fisheries Management
MNFH	Makah National Fish Hatchery
NMFS	National Marine Fisheries Service
NMML	National Marine Mammal Laboratory
NOR	Natural Origin Recruit
NWIFC	Northwest Indian Fisheries Commission
TRMP	Tribal Resource Management Plan
U&A	Usual and Accustomed Area
VSP	Viable Salmonid Populations

LAKE OZETTE SOCKEYE SALMON
<u>HATCHERY GENETIC MANAGEMENT PLAN</u>

INTRODUCTION

Background:

The National Marine Fisheries Service (NMFS) listed Lake Ozette sockeye salmon (*Oncorhynchus nerka*) as threatened under the Endangered Species Act (ESA) on March 25, 1999 (64 FR 14528). Total sockeye abundance within the evolutionarily significant unit (ESU) has been relatively stable or increasing in recent years with the help of the hatchery supplementation and reintroduction program. The run to Umbrella Creek has made a significant contribution toward overall abundance in recent years, averaging more than 10% of the total run size from 1995 to 1999. In 1999, the return to Umbrella Creek of approximately 400 spawners was approximately 15% of the total run size, with Umbrella Creek NOR spawners contributing approximately 6% of the total run size. Life history diversity and distribution of this ESU have all increased from reintroduction and suppplementation of the indigenous stocks. Despite this, artificial production poses some risks. This plan describes the goals, benefits and risks, operational procedures, and justification of hatchery production.

This Hatchery and Genetic Management Plan represents work conducted over the past two years combined with the long-term research efforts of the Makah Tribe in the Lake Ozette Basin since the 1970's. This plan presents a recent comprehensive review of adult Lake Ozette sockeye abundance and interfaces with work being conducted by the Habitat Work Group under the Lake Ozette Sockeye Steering Committee. This group has been working to identify and address limiting factors and factors for decline of Lake Ozette sockeye. This plan presents methods to increase and monitor abundance of all aggregations of Lake Ozette sockeye, attain recovery of the ESU, monitor and assess risks, and employ adaptive management. Research priorities are identified and results of recent findings are illustrated.

This plan addresses only one aspect of the complex factors for decline of Lake Ozette sockeye salmon. The term decline here and elsewhere within this document refers to the decline in viability of Lake Ozette sockeye salmon which includes parameters of abundance, productivity, spatial distribution, and diversity.The cumulative effects of intensive land-use practices within the last century and continuing presently, particularly extensive logging and associated road building, are thought to be a major factor limiting the productivity of naturally-produced sockeye salmon within the lake and its tributaries. It is believed that these habitat changes resulted in loss of quantity and quality of spawning and incubation habitat on lake beaches and in tributaries.

Artificial production can be useful for overcoming habitat limitations during spawning and incubation while habitat restoration actions are being developed, tested, and implemented, by planting existing habitat of suitable quality and after restoration has been completed by reseeding restored habitats. Known releases of hatchery fish planted into restored habitats and resulting changes in productivity can be measured before and after restoration activities are implemented. Habitat productivity models are under development in the comprehensive salmon management plans to link productivity to changes in habitat due to restoration or perturbation.

Factors for decline in addition to loss of adequate quality and quantity of spawning and rearing habitat are thought to include: 1) predation and disruption of natural predator–prey relationships; 2) introduction of non–native fish and plant species; 3) past over-exploitation (there has been no directed harvest for the past 16 years); 4) poor ocean conditions; and 5) the interactions of these factors. In the tributaries and on certain lake beaches, these factors resulted in extirpation of the locally adapted spawning aggregations and the life histories necessary for successful tributary spawning. Artificial production is also useful for reintroducing fish to streams and lake beaches where they have been extirpated and where suitable habitat remains.

Recovery Goals:

The overall goal of the Lake Ozette sockeye salmon recovery plan must be to restore properly functioning habitat conditions and spawning aggregations within the watershed to levels that maintain the ecological health and diversity of the watersheds and aquatic ecosystems on private and on public lands. This HGMP and associated biological monitoring and research coupled with the habitat component of the overall recovery plan under development advocates a comprehensive ecosystem approach which will integrate findings from freshwater, marine, and terrestrial environments. Recent publications which have synthesized these findings to link salmon restoration with interactions among salmon and the other aquatic and terrestrial species that they coexist with (Johnson and O'Neil 2000) are recognized as essential components of a comprehensive recovery plan. The goals of the Lake Ozette hatchery program are part of this overall plan. These goals are:

1) to prevent further decline of the ESU;
2) to increase abundance of naturally spawning Lake Ozette sockeye salmon to self-sustaining levels that meet future estimated escapement goals and enable sustainable Tribal and non-Tribal commercial, C&S, and sport fisheries;
3) to conserve the genetic and ecological characteristics of Lake Ozette sockeye salmon; and
4) to increase distribution and diversity of Lake Ozette sockeye salmon in their present and historic localities along the lakeshore of Lake Ozette and it's tributaries using supplementation, reintroduction, and natural colonization.
5) Rebuild naturally-spawning aggregations of sockeye in the Ozette Basin and restore their role in ecological processes, including nutrient recycling, serving as a source of prey for other species of fish and wildlife, and for traditional native uses.

Overall Approach:

The overall approach of this plan is based on adaptive management and risk management. Lack of complete knowledge about the Lake Ozette ecosystem introduces considerable uncertainty into choosing the best recovery strategies. Use of adaptive management means that recovery and restoration activities are treated as experiments that plan for unanticipated outcomes and generate knowledge that can be used to change or refine future actions (Figure 1). It has four main steps:

- Identifying recovery strategies that test hypothesis about the limiting factors or causes for decline of the population;
- Designing recovery activities as experiments to collect information from which we can learn;
- Analyzing the responses to recovery activities;
- Implementing changes based on synthesis of information and adaptive management.

Program Strategy:

This HGMP addresses the parameters affecting viability, forms hypotheses to improve survival and recovery of the ESU, and conducts risk management, monitoring, and adaptive management to minimize risks while ensuring that the recovery actions themselves are designed to accomplish the goals of the project while eliminating or reducing negative impacts.

To accomplish the project goals, the HGMP program strategy has two different components:

1) Reintroduction and supplementation efforts directed in Big River and Umbrella Creek using tributary returns for brood stock, with intensive monitoring of the experimental introductions to clearly understand their outcome. The intent is that reintroduction into these tributaries will increase viability (abundance, productivity, spatial structure, and diversity) of Lake Ozette sockeye, which

should be of long term benefit to the success of the population.

2) Limit artificial production activities for beach spawning fish to studies of limiting factors, genetic composition, and life history using methods described in this HGMP. Determinations of whether and how to supplement or reintroduce lake aggregations will be made pending results of the research.

It is understood that this HGMP alone, in the absence of habitat protection, assessment, and restoration; will not by itself lead to recovery. This HGMP is only a part of the co-manager's overall recovery plan under development, which itself is also a two-part plan integrating both hatchery and habitat components. Section 2.4 of this plan is entitled, "Relationship to habitat protection and recovery strategies." This section describes the coordinated approach by which this HGMP and the Lake Ozette Sockeye Recovery Plan integrate habitat and hatchery components. This section describes in detail how current and future habitat protection and restoration efforts will continue to recover habitat through active and natural processes. Through close coordination with the habitat component of the overall Lake Ozette Sockeye Recovery Plan, this HGMP addresses limiting factors that will promote recovery through the generation and assurance of self sustaining populations.

Although not part of the scope of the NMFS HGMP template, this HGMP identifies limiting factors, describes how the plan will address limiting factors, and explains how these actions interrelate with coordinated habitat restoration efforts, with the goal to achieve natural spawning populations, on 88 different pages. Appendix A (Pages 194 to 196) is a draft list of ranked limiting factors by life history stage. Appendix B (Pages 197 to 204) is a ranked list of research priorities to address the limiting factors by life stage. Appendix C (Pages 205 to 216) describes ecological interactions which include analyses of limiting factors such as competition, disease, and predation. The NMFS Biological Opinion, included as Attachment 1 to the HGMP, addresses limiting factors in work currently being conducted with returning Lake Ozette adult sockeye (predation studies, migration and holding mortality, distribution, abundance, and reproductive success studies).

Different considerations of how the program affects natural fish in ways leading to productive natural spawning populations of Ozette sockeye can be found on 29 pages in this HGMP including Sections 2.2, 2.2.4, 2.2.5, 5.2.3, 9.2, 10.4.1, 10.4.2, 10.4.3, and 10.4.6. In the overall co-manager recovery planning effort, MFM Habitat and Hatchery Divisions and the Habitat Technical Work Group have recently prepared a draft limiting factors paper. These coordinated efforts, complemented by the focus of this HGMP on increasing natural origin recruitment and viability, are the footstones of the overall Lake Ozette Sockeye Recovery Plan.

Risk Management:

Bold experiments in the face of uncertain knowledge of the parameters effecting viability of an ESU; however, may pose risks. In a complex ecosystem with many potential causes for decline, many different hypotheses are possible and some, such as doing nothing, may even be detrimental or provide no useful knowledge if pursued. The use of artificial production to recover natural spawning aggregations is an inexact and uncertain activity. These risks are managed in two ways. First, priorities for recovery actions (hypotheses) are based on methods that will prevent extinction of the species and increase our knowledge in the face of doing nothing. Second, recovery actions themselves are designed to limit potential unexpected or negative impacts.

Limiting potential negative impacts is based on a two-pronged strategy of: 1) choosing actions that lower the probability of an unwanted event occurring and 2) minimizing the losses of an event if it does occur (Currens and Busack 1995). Consequently, in both the tributary reintroduction program and the beach supplementation program, different proposed methods for collecting, mating, rearing, and releasing fish; the theoretical risks of each are examined; and the actions that help minimize the probability of an adverse impact are identified while accomplishing the goals of the project. Minimizing the losses if an unwanted event occurring depends on 1) having the ability to detect and respond to an adverse impact and 2) having biological reserves or buffers (Currens and

Busack 1995). Consequently, both the tributary reintroduction program and the beach supplementation programs rely extensively on monitoring and buffering adverse effects.

Working Hypotheses:

A major working hypothesis for recovery strategies in Lake Ozette is that the cumulative effects of intensive land-use practices within the last century and continuing presently are limiting the productivity of naturally produced sockeye salmon, especially during spawning, incubation, and emergence, within the lake and in its tributaries. The overall adaptive management approach for habitat will be described in the Lake Ozette Sockeye Recovery Plan. However, it is unlikely to solve all problems or to even determine many solutions in the short term. Artificial production may be a more immediate, useful way to test and quantify the limiting factors, prevent short-term risks of extinction, and increase distribution and diversity.

The working hypothesis of this plan is that the abundance, distribution, and diversity of Lake Ozette sockeye salmon can be increased by supplementation and reintroduction in their present and historic localities. This has two parts:

- To test whether sockeye salmon can be reintroduced into tributary spawning habitat, and
- Pending results of limiting factor experiments, genetic composition analyses, and life history studies of adult sockeye using hatchery methods, determine whether supplementation can rebuild beach spawning aggregations and expand spawning to currently unused beaches.

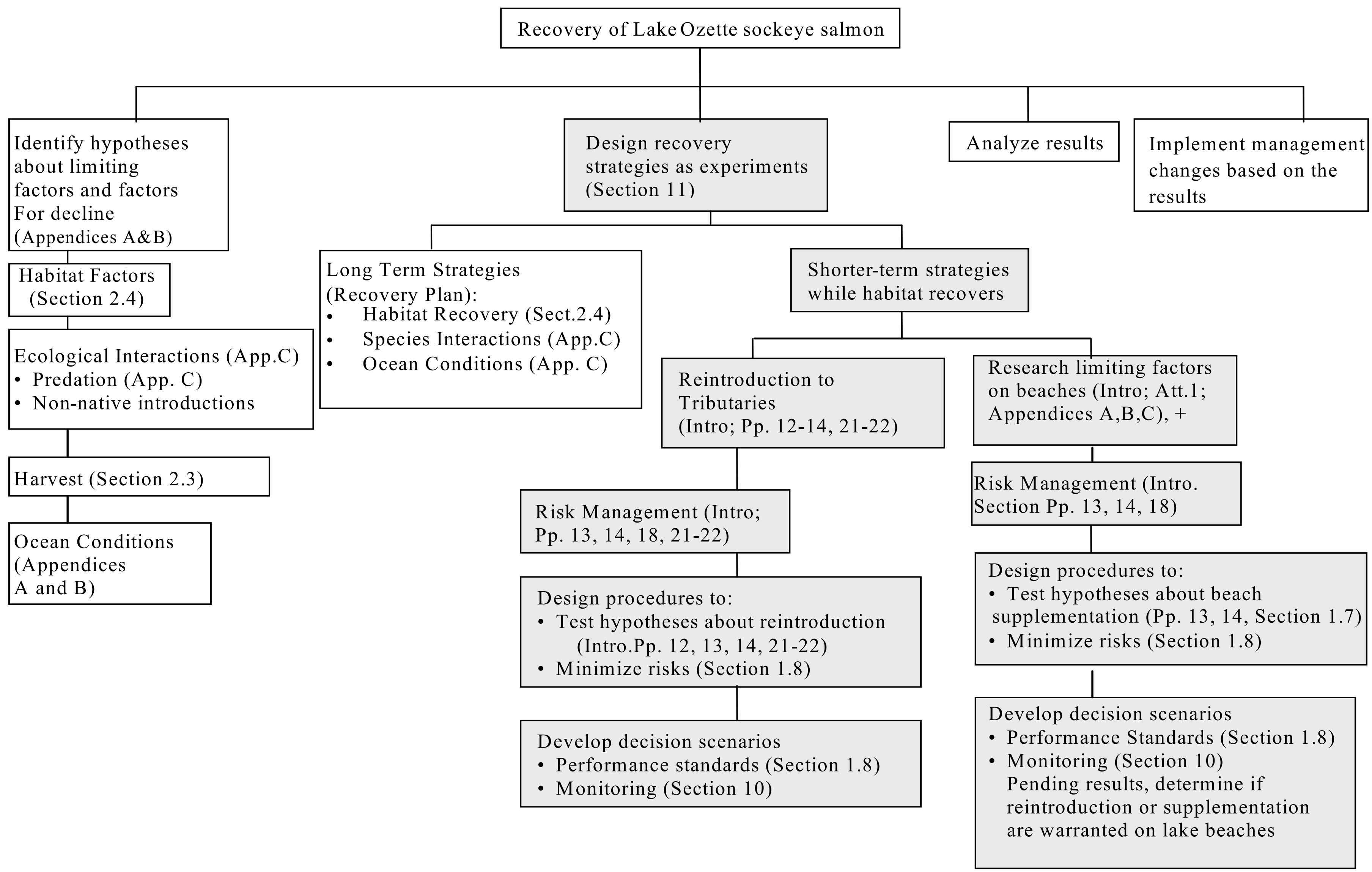


Figure 1. Adaptive management approach for using artificial production to help recover Lake Ozette sockeye salmon.

Rationale:

An alternative hypotheses for recovery is that sockeye salmon will increase in abundance, distribution, and diversity on the beaches and in the tributaries without use of artificial production. Based on the risk management priority discussed above (that actions to prevent extinction of the species and increase our knowledge are preferable to doing and learning nothing), we believe that the use for artificial production is an essential test of recovery. The Final Rule published in the Federal Register (FR 63, No. 46 11750), Jacobs *et al.* (1996), Dlugokenski *et al.* (1981), Blum (1988), and numerous other published and unpublished reports state that if recent conditions continue, Lake Ozette sockeye salmon are likely to become threatened or to become extinct in the foreseeable future.

Comprehensive, effective habitat recovery actions have yet to be developed and implemented. Given existing conditions and the extensive clear cut logging which has occurred and continues to occur, it is likely that habitat factors adversely affecting sockeye productivity in the basin will not be remedied in the near future. Less productive beach spawning aggregations may be likely to go extinct without immediate intervention. Tributary spawning aggregations as well as other tributary outlet spawners and other beach spawning aggregations of Lake Ozette sockeye salmon were presumed to have gone extinct prior to the initiation of hatchery supplementation, which began in 1982.

Despite the apparent need to intervene with artificial production, we propose to move cautiously. The two objectives of this plan — reintroducing sockeye salmon to the tributaries and studying limiting factors to determine if increasing the production and distribution of beach spawners is necessary, have different critical uncertainties, benefits, and risks. We examined these in developing the risk management and rationale for using artificial production (Table 1). These are summarized below and will be described in more detail in the following section of this plan.

Supplementation of Beach Spawners:

Critical Uncertainties

Successful supplementation of beach spawners depends on several critical uncertainties: 1) Do the trends in abundance warrant intervention? 2) Is productivity limiting at a life-stage that can be addressed by supplementation? 3) Are the different spawning aggregations different spawning populations?

1. Abundance:

Abundance estimates in Jacobs *et al.* (1996) vastly underestimated adult abundance (see Section 2.2.2). These data were used in the determination of the threatened status and listing of Ozette sockeye, placing mean run size below 1,000 fish and low abundance years at only a few hundred fish. Using recent abundance estimates from 1996 to 1999, the run averaged 1,598 adult sockeye (range 1,133 to 2,076). Based on a small amount of camera data in early May, 2000, it appears that if the 2000 return continues to follow the same run timing of the cumulative abundance curve generated from the 1999 return, the most recent four year average from 1997 to 2000 could exceed 2,000 adults with low abundance years well above 1,000 adults (MFM unpublished data). The actual trends in abundance for each of the spawning aggregations within the basin will not be known conclusively for several years as more accurate camera data on lake escapement and more comprehensive hydroacoustic, snorkel, and scuba surveys, and sonic tracking of spawners are conducted. Returns to Umbrella Creek (a new tributary spawning aggregation) indicate increasing numbers of natural origin recruites (NOR). These trends will continue to be monitored with sufficient marking to allow for monitoring and evaluation using time lapse video monitoring, spawner surveys, and carcass recoveries.

The current trends in abundance of any of the beach spawning aggregations are unknown. Although overall abundance appears to have declined from historical levels, it is unknown how this has affected the individual spawning aggregations. This includes the two known beach spawning aggregations, as well as other beaches and outwash fans where ripe sockeye have been observed in the past, such as Umbrella Beach, Ericson's Bay, Baby Island, and Boot Bay. Extremely limited numbers of ripe adults have been observed on these beaches, but few surveys have been conducted at any of these sites.

By subtracting Umbrella Creek annual escapement estimates (Section 2.2.3; Table 7) from corresponding annual run sizes (Section 2.2.2; Tables 5 and 6), the potential mean abundance of natural beach spawners from 1996 to 1999 (before natural mortality) appears to have exceeded 1,400 adult sockeye. The projected mean abundance of natural beach spawners from 1997 to 2000 may exceed 1,500 due to a relatively large return projected in 2000. Without knowing mortality rates prior to spawning, which is an extended period, it has not been possible to determine the survival rate from lake entry through spawning up to the time of this writing. Since accurate estimates of the overall run size are not available for consecutive four-year brood cycles, trends in overall abundance and productivity are unclear, but can be determined in the future from the new underwater video camera methods. The abundance and productivity of beach spawning aggregations are unknown but are under investigation. Adult tagging and hydroacoustic research planned in 2000/2001 should help to gain a better understanding of spawner abundances on the lake beaches.

Table 1. Summary of critical uncertainties, benefits, risks, and risk management for Lake Ozette sockeye salmon artificial production.

Group: Status	**Assumptions**	**Critical Uncertainties**	**Benefits**	**Risks**	**Risk Management**
Tributaries: Native population extinct; Reintroduced NOR's listed under ESA	• Habitat is available or in the process of being restored • Potential for natural recolonization from beaches during recovery period is very low	• Beach spawners can adapt to tributaries	• Increase abundance • Increase diversity • Expanded distribution • Increase nutrient flow to tributaries	• Brood stock mining • Hybridization with kokanee • Straying to beach spawning aggregations	• Use non-listed hatchery fish as brood stock • Limit experimental introductions to tributaries that have little or no kokanee and possess suitable habitat for sockeye • Monitor hybridization • Monitor straying
Beaches: Extant lake spawners listed as threatened under ESA	• Habitat is available or in the process of being restored • Potential for natural recolonization to new beaches during recovery period is very low	• Abundance • Spawning aggregation structure • Life-stage at which productivity is limited	• Increase abundance • Expanded distribution	• Brood stock mining • Loss of diversity among spawning aggregations • Loss of within population diversity • Domestication and loss of fitness in the wild	• Ensure that any future collections are representative of donor spawning aggregation. • Limit brood stock collections to small numbers on both beaches strictly for research in the near term. Pending results, develop further recovery strategies. • Use multiple facilities • Rear for the minimum time. • Use factorial matings • Monitor post-release survival. • Monitor straying

Depending upon the abundance trends, spatial distributions, and diversity of these small spawning aggregations, and whether they are separate subpopulations, hatchery supplementation may be essential for their recovery.

In March 1999, NMFS concluded in the Final that the Umbrella Creek Hatchery population was not essential for recovery of the ESU (FR 64 14528). The decision by NMFS that the hatchery fish weren't essential for recovery, "was influenced by the presence of significant numbers of sockeye salmon still spawning naturally on Olsen's Beach and in Allen's Bay in Ozette Lake; these fish could be used in recovery efforts." However, the abundance, productivity, spatial distribution, and diversity of currently known and historic spawning aggregations of sockeye salmon in Lake Ozette is unknown. Also, there appears to be numerous applications where hatchery fish may be essential for recovery of the ESU.

2. Limiting Factors by Life Stage:

A preliminary ranking of limiting factors by impacts on life stage was recently developed by the Lake Ozette Habitat Technical Work Group and modified by MFM in 1999 (Appendix A). A preliminary list of ranked research needs by life stage was also developed by the Lake Ozette Habitat Technical Work Group and modified by MFM in 1999 (Appendix B). Potential limiting factors include: loss of spawning habitat and productivity, marine mammal, fish, and bird predation and disruption of natural predator–prey relationships, poor ocean conditions, introduction of non–native fish and plant species, past over-exploitation (there have been no directed harvests for the past 16 years); and the interactions of these factors.

The decreased productivity of the currently known beach spawning sites may be attributed to reduced spawning habitat quality and area. The primary spawning area on Olsen's Beach, the largest known beach spawning aggregation in Lake Ozette, is only 300 m^2 and is located on the only appreciable upwelling area at this site. Secondary spawning areas at this site appear to be limited by wave action to provide irrigation to the eggs and appear to be limited to very few spawners. The increasing abundance of naturally reproducing Lake Ozette sockeye in Umbrella Creek and the intense spawning competition and redd superimposition at Olsen's Beach (Dlugokenski *et al.* 1981, MFM unpublished data, MFM *in progress*), suggests that the limiting factors for sockeye are associated more with the productivity of the incubation habitat rather than with the productivity of juvenile lake rearing habitat. Beauchamp *et al.* (1995) found that food availability and competition is unlikely to limit sockeye smolt production. Furthermore, the large size (120mm) of out-migrating sockeye smolts (Dlugokenski *et al.* 1981, MFM 1990; Jacobs *et al*. 1996), and the relatively large quantity of zooplankton relative to other sockeye producing lakes in Washington and Alaska (Bortleson and Dion 1979; Jacobs *et al*. 1996) further indicates that food supplies in Lake Ozette are not limiting.

Other evidence also suggests that sockeye salmon productivity is limited during the spawning and incubation life stage. High levels (17.1% average for Ozette tributaries) of fine sediment (<.85mm) within spawning gravels may compromise egg-to-emergence survival of Ozette sockeye within Big River and Umbrella Creek (McHenry *et al.* 1994) and the lake beaches (Makah Fisheries Management, *work in progress*). This sediment has several sources. For example, McHenry *et al.* (1994) found that road densities within the Ozette Basin were approximately 2.2 km/km2. Road systems within the basin have a high connectivity with streams (lack appropriate cross-drains) and may be a substantial source for the high levels of fine sediment observed in the streams. In addition, lack of a fully functional riparian forest along tributaries to Lake Ozette is presumed to contribute to channel destabilization, loss of pool quantity and quality, increased scour, and increased summer temperatures. The introduction and invasion of non- native plant species, such as reed canary grass, and encroachment of native plants, such as willow and sedge species, along the tributaries and spawning beaches within Lake Ozette, coupled with increased levels of fine sediment delivered to beaches via tributaries that allow the plants to root and in turn trap more sediment, are compounding plausible factors for decline (MFM unpublished data; Adkinson and Burger In Jacobs *et al.* 1996).

3. Population Structure:

The need for future hatchery intervention and the strategy employed may also depend on whether the different beach spawning aggregations are one or multiple subpopulations. Sockeye salmon currently spawn on Olsen's Beach and Allen's Bay Beach and may potentially spawn on other undocumented beaches. If they are a panmictic population, then small numbers of spawners on satellite beaches do not necessarily represent an increased risk of extinction or need for immediate intervention. If they are distinct subpopulations; however, decreasing numbers of spawners may result in extinction of unique components of the ESU and call for intervention. The likelihood that the ESU is in decline may not be supported. Recent run size data suggests that some aggregations are stable or increasing.

The two known aggregations are currently treated as separate populations, but scientific support for this is inconclusive. The NMFS noted significant differences in allozyme frequencies between spawners from the two locations, which might suggest different populations (Gustafson *et al.* 1997). Significant differences between samples from the same location in different years; however, may suggest that presumed geographical differences were actually temporal variations in the same spawning aggregation. Whether these are one population or two also has significant implications in the management of future lake beach reintroduction and supplementation plans regarding how and where brood stock are selected and for the methods and locations that their progeny are released to reduce risks to natural beach spawning fish. Initial funding for genetic monitoring was recently procured by NWIFC and MFM to undertake baseline DNA characterization of *O. nerka* spawning aggregations within the Ozette Basin (Attachment 2; Section 12).

Risk Management:

Several risks were identified with potential future supplementation of beach spawning aggregations (Table 1) and a strategy was developed to minimize these risks. The focus of artificial production in Lake Ozette in the near future will be to test whether spawning and incubation success are limiting factors in sockeye salmon production on lake spawning beaches. With adult returns to Umbrella and Crooked Creeks being the source of all brood stock for the tributary program, the issue of brood stock mining is eliminated or reduced to the take of only a few pairs of lake-origin adult returns for research experiments with their progeny to study limiting factors.

Capture methods from lake beaches were refined in recent years to not overharvest or harass the potential donor beach by not exceeding catch or recapture limits, while minimizing the potential of mortality resulting in fish captured and released (Appendix D). No brood stock have been collected from Allen's Beach for supplementation since 1997. In the near future, no brood stock will be collected from any lake beaches other than small numbers for experimental purposes. Additional spawners will be captured and released upon removing a fin clip for genetic analysis as previously described, with emphasis on first collecting samples from carcasses and spawnouts. Tissue samples for genetic analysis will be collected from all carcasses recovered as the preferred source of samples. Collections of live adults will be minimized to only supplement only those not provided from carcasses, to provide adequate numbers of samples for genetic analyses as described in Attachment 2.

In addition to the genetic analyses and limiting factors experiments during early incubation and rearing, research will begin in 2000 to identify limiting factors, spawner success, behavior and life history of adults during their freshwater migration, holding, and spawning in the Ozette River and in the lake. Any future lake supplementation and/or reintroduction will occur only after sufficient research has been conducted to establish that there are significant expected benefits relative to minimal risk of harm. An incremental approach will be taken if and when supplementation of lake beaches is determined to be beneficial to survival and recovery of the Lake Ozette sockeye ESU.

Potential loss of genetic diversity in the hatchery will be minimized by using appropriate numbers of spawners and modified factorial mating (Currens *et al.* 1988). Domestication will be minimized by rearing the fish for the minimum length of time possible before releasing them, integrating wild brood stock, and limiting the duration of the program. Sufficient numbers of sockeye produced by the hatchery program will be otolith-marked. Sufficient numbers of fingerlings, reared above a size of 0.5 grams, will also be fin clipped. Unique marks will be applied to differentiate release strategies. Hatchery origin sockeye will then be identified first by video camera in the Ozette River and then by otolith recovery and fin clip incidence of spawners and carcasses. Carcass and spawner recoveries on spawning grounds will facilitate determination of relative hatchery and NOR run size contributions and stray rates.

Reintroduction to Tributaries:

Critical Uncertainty:

Successful reintroduction to the tributaries depends on a fundamental critical uncertainty: can introduced beach spawners adapt to tributary environments? Recent returns and historical evidence indicate that sockeye spawned in the tributaries as well as on numerous beaches. The Makah Tribe is convinced that it is vital to increase the abundance, productivity, distribution, and diversity of sockeye salmon in Lake Ozette by reintroducing sockeye to vacant, suitable, beach and tributary habitats. Jacobs *et al.* (1996) noted that one of the primary factors for decline of the ESU was "the demise of certain life history types." Risk of extinction was compounded by loss of tributary spawners combined with the likelihood that "the lake spawning population may be faced with continued decline in the quality of its spawning environment." The panel of nationally recognized scientists emphasized the importance of the "establishment or re-establishment of tributary spawners." Reintroduction of sockeye salmon to the tributaries is also consistent with National Marine Fisheries Service's vision of viable salmon populations (McElhany *et al.* 1999). If extant spawning aggregations were left on their own to recolonize vacant habitats, it is possible that it would take hundreds or even perhaps thousands of years to occur, if ever. The Makah Tribe does not want to sacrifice the vital tribal resources once provided by these fish by waiting indefinitely for a resource to reappear that was destroyed in less than a century.

Evidence suggests that reintroduction of sockeye salmon to the tributaries using beach spawners has succeeded despite the adaptive challenges to the fish. The scientific literature hypothesizes that genetic and phenotypic divergence is maintained among lake and tributary ecological forms of sockeye salmon by mechanisms that dictate salmonid spawning and fry emergence timing (Brannon 1987). Sockeye salmon releases have resulted in a tributary spawning aggregation comprised of natural origin recruits (NORs) and returns from hatchery releases (Table 7; Section 2.2.3). Thus, natural reproduction in Umbrella Creek appears to be successful.

In 1996, 101 sockeye salmon spawned in Umbrella Creek. Because the vast majority of adult sockeye salmon that return to Lake Ozette are four- year-olds, and because no hatchery progeny were released from brood year 1992, nearly all 1996 spawners observed in Umbrella Creek were presumed to have been natural origin recruits. In brood year 1999-2000, the estimated number of sockeye salmon spawning in Umbrella Creek was approximately 400. The percentage of NOR's in Umbrella Creek in 1999 was estimated to be between 21.4% and 52.9%. The high variability in this estimate is due to difficulty in identification of adipose fin clips in hatchery origin fish. (A minimum of 47.1% (24/51) of the fish were of hatchery origin based on positive identification of adipose clips (Section 2.2.3), but if all fish with questionable adipose fin shapes were included, a maximum of 78.6% (44/56) may have been hatchery returns). Assuming approximately 37.2% (midpoint of range) of the fish were NOR's, there were approximately 52 NORs/mile surveyed and a total of 149 of natural origin. In 1995 (the brood year that produced these fish), only 19 fish were observed per mile. This roughly yields a spawner-replacement ratio of 2.7 (52/19).

Although the evidence is limited to a few years of data, it suggests that the Umbrella Creek spawning aggregation is growing and that these fish may either be rapidly adapting to the tributary environment or already had the necessary ecological adaptations. This is important, because use of tributary spawners to replace beach spawners as the source for brood stock for ongoing tributary reintroduction may speed recolonization while simultaneously reducing take on lake spawners. Furthermore, the apparent increases in natural origin recruits to the ESU suggest that reintroduction should be given considerable weight in designing future recovery plans for Lake Ozette sockeye.

Risk Management:

Reintroduction to the tributaries can provide enormous benefits to the ESU. Several risks were identified (Table 1) and a strategy was developed to minimize the risks. Potential brood stock mining of the listed beach spawning aggregations will be minimized by using the introduced tributary fish returning to Umbrella and Crooked Creeks. Potential loss of genetic diversity in the hatchery is minimized by using appropriate numbers of spawners and factorial matings (Currens *et al.* 1998). Domestication will be minimized by rearing fish the minimum time possible, integrating wild brood stock as their numbers increase, limiting the duration of the program, and maintaining high productivity in wild spawning fish.

An additional concern was that reintroducing sockeye to the tributaries of Lake Ozette might lead to hybridization with kokanee salmon (nonanadromous sockeye salmon), which are genetically distinct and not part of the ESU. Sneak spawning by kokanee males with sockeye females has been shown to contribute to fertilization rates averaging better than 20% in streams with healthy kokanee populations (Wood and Foote 1996), although genetic data suggest that little or no hybridization has occurred in Lake Ozette (Gustafson *et al.* 1997). If hybridization did occur, however, it could theoretically lead to reduced fitness in the hybrids and introgression with beach spawning fish (Gustafson 1999).

To address this concern, reintroduction is limited to streams with little or no kokanee. Makah biologists surveyed potential tributaries in 1999 for kokanee abundance and suitable sockeye habitat and identified Big River and Umbrella Creek as candidates with good sockeye habitat and no spawning populations of kokanee. Very few kokanee-sized fish have been observed in these streams, no “spawning populations” have been observed, and none have been observed spawning with sockeye. For example, of approximately 400 sockeye counted in Umbrella Creek in 1999, only three kokanee-sized fish were observed (estimated to be approximately 12 inches in length which is very large for kokanee). None were observed to be spawning with sockeye. Another seven fish observed in the survey were considered jacks (yearling anadromous sockeye salmon) because of their size (14-16 inches in length) and the observation that more than 100 anadromous jack-sized sockeye were observed entering Lake Ozette from saltwater by the underwater video camera at the weir in 1999.

Potential hybridization and straying will also be monitored. The Tribe recently secured initial funding to begin to establish a DNA baseline for sockeye and kokanee salmon needed for the genetic monitoring program (Attachment 2; Section 12). Straying will be monitored by intensive spawner surveys on Olsen’s and Allen’s beaches for hatchery-origin strays by analyzing otoliths from all carcasses recovered. Sufficient numbers of sockeye produced by the hatchery program will be otolith-marked. Sufficient numbers of fingerlings, reared above a size of 0.5 grams, will also be fin clipped. Despite applying for funding to mark otoliths as required to monitor the fish (Attachment 2; Section 12), the Makah Tribe has not been able as of yet to procure funding (the first year of the project described in Attachment 2 was funded only for genetic work but not for otolith analyses). In spite of this lack of funding, the Tribe paid more than $10,000 in brood years 1998 and 1999 to mark fish, collect otoliths, have otoliths read, and to provide equipment for otolith marking such as generators, electrical wiring, chillers or heaters, and other equipment. Future hatchery reform dollars should become available for this desperately needed monitoring. Support from NMFS to the HSRG to fund Lake Ozette sockeye otolith monitoring work in the future is needed and will be greatly appreciated.

Why Natural Production in the Lake Ozette Tributaries Must Contribute Toward Recovery

Natural production in Lake Ozette tributaries must contribute toward recovery of the ESU. A review was conducted to evaluate reintroduction of sockeye salmon into tributaries of Lake Ozette for consistency with recovery guidelines under the NMFS application of the ESA. Natural origin recruits originating from tributary spawners are listed under the ESA and the tributaries to Lake Ozette are designated critical habitat for the listed ESU. The NMFS has identified general guidelines for four critical population parameters that can be used to assess viable salmonid populations (VSP) for recovery (McElhany *et al.* 1999). These parameters are: 1) population size, 2) trends and productivity, 3) spatial structure, and 4) diversity. Guidelines for these parameters are based on an extensive review of the conservation biology and salmonid literature. The NMFS has asked technical recovery teams to use these guidelines and parameters in developing recovery goals (NMFS 2000). Although the ESA focus is on recovering lake spawners, bolstering tributary production will have a positive effect on population size, productivity, spatial structure, and diversity of the ESU.

Reestablishing natural sockeye salmon spawning aggregations in the tributaries is consistent with VSP guidelines for abundance. Guidelines for abundance emphasize that abundance must be large enough for the population to survive environmental variation, to provide resilience to anthropogenic perturbation, to maintain genetic diversity, and to provide important ecological functions. Successful reestablishment of naturally spawning sockeye salmon in the tributaries from natural spawning aggregations in the lake would increase the overall abundance of the ESU.

Reestablishing natural sockeye salmon spawning aggregations in the tributaries is consistent with VSP guidelines for productivity and trends in abundance. These guidelines emphasize that productivity must be high enough for natural production to be self-sustaining and changes in phenotypic variation in the population should not portend reduced intrinsic productivity. As sockeye continue to colonize Lake Ozette tributaries, overall productivity is expected to increase, because realized productivity in the tributaries will be high during the density independent, colonization phase of population growth. Limited data from Umbrella Creek suggest that this is happening. Intrinsic productivity of the tributaries spawning aggregations is also expected to increase as the fish become adapted to this new environment.

Reestablishing natural sockeye salmon spawning aggregations in the tributaries is consistent with VSP guidelines for spatial structure. Guidelines for spatial structure emphasize that source populations should be maintained, historical spatial processes should be preserved, that natural rates of straying should not increase among spawning aggregations as a result of human actions, and that habitat patches be maintained. Successful reestablishment of sockeye salmon in the tributaries is intended to expand spatial distribution of natural production in the ESU and not replace or interfere with natural production on the beaches, which are the extant source. Although the historical data do not give us a very good picture of historical spatial processes, anecdotes, recorded interviews and oral histories of Makah Tribal elders suggest that sockeye salmon spawned in the tributaries to the lake early in this century before being extirpated. Consequently, reintroduction to the tributaries where there is suitable habitat is also consistent with attempting to recover historical spatial processes. Reintroduction by humans is unlikely to lead to straying that would negatively affect the population's viability by interbreeding with genetically unrelated fish. No straying of tributary returning, hatchery-origin, adults to the lake beaches was observed in the 1999 return, which is the only return year where marked hatchery-origin returning adults were monitored in the lake spawning aggregations after a tributary release. The only population is the source population that is being used for reintroduction. Reintroduction efforts will be closely monitored and managed to maintain the population structure.

Reestablishing natural sockeye salmon spawning aggregations in the tributaries is consistent with VSP guidelines for diversity. Guidelines for diversity emphasize that human-caused actions should not substantially alter diversity of traits of existing spawning aggregations and that natural processes of dispersal and causes of ecological variation should be maintained. Reintroduction of sockeye salmon to the tributaries is expected to increase the diversity of life history traits, morphology, behavior, and molecular genetic structure within the ESU. Sockeye are expected to adapt to those conditions, resulting in changes in phenotypic and genotypic diversity from their source spawning aggregation. These changes should not affect the diversity of the existing population but should provide evolutionary benefit and resilience to the whole ESU, which is consistent with VSP. As fish colonize new habitats and evolve in new environments, natural dispersal processes may also evolve. The current processes of dispersal within the ESU, which has been reduced to a few spawning aggregations, are poorly understood, and are unlikely to represent the natural processes of a whole, recovered ESU. Although existing natural patterns of dispersal may change, it will be essential, however, to protect the diversity of the extant lake spawning aggregation(s) as this happens.

SECTION 1. GENERAL PROGRAM DESCRIPTION

1.1) Name of Program:

Lake Ozette Sockeye Recovery Plan: Lake Ozette Sockeye Hatchery and Genetic Management Plan

1.2) Population (or stock) and species:

Lake Ozette sockeye salmon (*Oncorhynchus nerka*).

1.3) Responsible organization and individual:

Name(and title):	Russell A. Svec, Fisheries Program Manager
Organization:	Makah Fisheries Management
Address:	P.O. Box 115, Neah Bay, WA. 98357
Telephone:	(360) 645-3156
Fax:	(360) 645-2323
Email:	coho@olypen.com, haggerty@olypen.com, aritchie@centurytel.net

Other organizations involved, and extent of involvement in the program:

Until 1999, funding and execution of this HGMP for supplementation and reintroduction of Lake Ozette sockeye in the Ozette Basin and associated research, M&E, and adaptive management has been conducted by the Makah Fisheries Management (MFM) Department of the Makah Natural Resources Department. In 1999, collaborative projects for research, recovery, and habitat restoration projects in the Basin are under development or have been initiated among parties of the Habitat and Supplementation Technical Work Groups under the Lake Ozette Sockeye Steering Committee.

1.4) Location(s) of hatchery and associated facilities:

Include state and basin, regional mark processing center code, and sufficient information for GIS entry. See Instruction C above and use this section to provide information. Describe the role of each.

Umbrella Creek Hatchery

Hatchery Name	Umbrella Creek Hatchery
State	Washington
Basin	WRIA 20 Quillayute-Hoh
Watershed	WRIA 20.0056, tributary to Umbrella Creek
Disease Management Unit	Fish Health Management Zone 8
Regional Mark Processing Center Code	3F21704 200056 H

Umbrella Creek Brood Stock Holding:

During past lake collections, the Umbrella Creek Hatchery was used to hold green adult Lake Ozette sockeye each fall spawning season until the brood stock became ripe and were spawned. While some ripe adult sockeye may be collected riverside, green spawners collected from Umbrella

Creek, beginning in 2000, will be transported to holding tanks at the Umbrella Creek Hatchery in the same manner as described in Section 6.2.3, segregated by origin, and held until ripe.

Brood stock holding at the Umbrella Creek Hatchery has generally averaged seven to ten days per collection in past years with some spawned as early as within one day and some held as long as two to three weeks. In any future lake supplementation efforts, adult brood stock will be collected as described below in Section 6.2.3 during a two-month period from October through December each year, when pre-spawning sockeye may be captured in the vicinity of their natural spawning grounds. Unripe fish have not been observed in any significant numbers after this period (a total of one green fish was observed after December in 1998/1999 and 1999/2000, despite numerous attempts to locate more of this late-spawning component. Slightly unripe adults are preferred for brood stock because they can be held with little or no mortality and then spawned expediently as they become ripe. Egg survival has been found to be lower in ripe adult Lake Ozette sockeye due to reduced fertilization caused by over-ripe or water-hardened eggs found more often in ripe adults that have already begun spawning.

Umbrella Creek Egg Incubation, Hatching, Fry Rearing and Release:

Marked, eyed eggs not destined for egg plants onto beaches or into the two tributaries targeted for reintroduction and supplimentation by this program will be returned to the Umbrella Creek facility in late-January to mid-February each year for hatching, imprinting, and release into Umbrella Creek. Also, as in all years prior to the 1999/2000 season, green eggs may also be incubated at the Umbrella Creek Hatchery. Fry releases into Umbrella Creek will occur as otolith-marked, unfed fry (April; pending research), fed fry (May; pending research), and/or fingerling (June) releases into Umbrella Creek each season. Release strategies or locations may be adjusted for, or in response to, research or in response to adaptive management, in the evaluation of success in achieving performance standards for egg, unfed, fed fry, and fingerlings (~ 1 gram).

Educket Hatchery

Hatchery Name	Educket Creek Hatchery
State	Washington
Basin	WRIA 20 Quillayute-Hoh
Watershed	WRIA 20.0010, Educket Creek
Disease Management Unit	Fish Health Management Zone 8
Regional Mark Processing Center Code	3F21704 200010 H

The Educket isoincubation quarantine building will be used temporarily for the 1999-2000 and 2000-2001 brood years to reduce potential risks associated with losses due to disease or water failure by moving all eggs to this isoincubation quarantine facility beginning in 1999. Besides isoincubation, increased iodophor disinfection of eggs and chlorination of effluent will be possible to further prevent disease, monitoring will be improved due to increased proximity to staff, and otolith marking and water quality are the benefits of this facility. A detailed examination of safeguards available at this facility is discussed in Section 4.3 and water temperature is examined in Section 3.

Makah National Fish Hatchery

Hatchery Name	Makah National Fish Hatchery
State	Washington
Basin	WRIA 20 Quillayute-Hoh
Watershed	WRIA 20.0015, Sooes River
Disease Management Unit	Fish Health Management Zone 8
Regional Mark Processing Center Code	3F21704 200015 H

To reduce potential risks associated with losses due to disease or water failure, use of the U.S. Dept. of Interior Makah National Fish Hatchery (MNFH) isoincubation quarantine building is recommended beginning in the fall of 2001 to incubate green Ozette sockeye eggs to the eyed stage. A detailed examination of disease reduction benefits, genetic and ecological risk assessments is included in Section 4.3. Besides isoincubation, increased iodophor disinfection of eggs and chlorination of effluent will be possible to further prevent disease, monitoring will be improved due to increased proximity to staff, and improved otolith marking capabilities and better water quality are the benefits associated with this facility. A detailed examination of safeguards available at this facility is discussed in Section 4.3 and water temperature is examined in Section 3.

1.5) Type of program:

Integrated Recovery Program

1.6) Purpose (Goal) of program:

The intent of the Lake Ozette Sockeye Supplementation Program is to prevent and reverse any potential decline of the ESU and to conserve the genetic and ecological characteristics of existing spawning aggregations of Lake Ozette sockeye salmon within the basin. The goal of this program is to increase abundance of naturally spawning Ozette sockeye salmon to self-sustaining levels and to re-establish historic sockeye spawning abundance and distribution along the shore of Lake Ozette and it's tributaries. Abundance will meet future estimated escapement goals and culminate in sustainable fisheries.

1.7) Specific performance objective(s) of program:

Objectives are designed to achieve the program goal, and are generally measurable, realistic, and time specific. Example: The goal of this program will be achieved by (1) using supplementation to increase by five-fold the number of natural spawners in Deer Creek, by year 2012; (2)....; (3)....

See Table 2.

1.8) List of Performance Indicators designated by benefits and risks:

Performance indicators determine the degree that program objectives have been achieved, and provide the specific parameters to be monitored and evaluated.

Separate indicators into two categories of "benefits" and "risks" the hatchery program will provide to the listed species. Where possible, use indicator list already compiled in ESU-wide hatchery plan or other strategic plans.

Some indicators examples are (1) adult:adult replacement rates of program fish; (2) trends in spawning abundance in Deer Creek measured by natural return rates and egg-to-smolt survivals; (3) predation on other species by program fish as measured by stomach content analyses; (4) genetic effects on other populations by program fish as measured by stray rates; (5) etc.

See Table 2.

Table 2. Summary of performance standards and indicators targeted for risks (R) and benefits (B).

1.7) Standards	1.8) Indicators	Target
Abundance		
1. Estimates of current and historical abundance of Lake Ozette sockeye salmon are based on best available sampling and analysis.	1.1. Total annual counts of hatchery and wild origin sockeye at weir using under-water video. Comparison of camera with visual observations confirmed method and helps to hindcast previous year run sizes.	B
	1.2. Number and proportions of unmarked and marked (adipose clip, otolith mark) in annual video recordings of total run and in spawner surveys of beaches and tributaries.	B
	1.3. Number and origin of fish measured in systematic snorkel, scuba, and hydroacoustic surveys.	B
	1.4. Annual evaluation of proportion of fish successfully otolith marked.	B
2. Population sizes are at levels that will prevent further decline and extinction of the ESU.	2.1. Abundance and abundance trends of listed fish are above minimum viable levels.	R
3. Population sizes are at levels that will allow tribal and commercial fisheries.	3.1. Abundance and abundance trends of listed fish are above minimum escapement levels.	B
Natural Productivity		
4. Increase natural productivity of Lake Ozette sockeye salmon.	4.1. Abundance and increasing trends in abundance of NOR adults, and annual abundance, productivity (smolts/spawner), and origins of NOR smolts in Ozette River smolt trapping (annual monitoring).	B
	4.2. Abundance, increasing trends in abundance, and origins of NOR fry migrating from tributaries (monitored as needed).	B
5. Identify habitat limiting factors and conduct passive or active restoration.	5.1 Complete limiting factors analysis.	B
	5.2 Survival and mortality rates by life stage	R
	5.3 Survival and mortality rates relative to limiting factors before and after restoration	R
6. Determine if pinniped predation is ecologically sustainable or a limiting factor for recovery.	6.1 Scarring incidence in lower and upper river, species and umber of pinnipeds preying on sockeye salmon, number of salmon mortalities attributable to predation by sockeye life stage and subhabitat	R

1.7) Standards	1.8) Indicators	Target
Hatchery Productivity		
7. Brood stock captured and handled for artificial production provide maximum benefits to the program.	7.1. Pre-spawning mortality rates for capture, transfer, and holding methods reviewed.	R
	7.2. Daily proportion of healthy, ripe brood stock.	B
	7.3. Reproductive success of spawners.	B
	7.4. Cleanliness of well screen in impoundment pond.	R
	7.5. Consistency of brood stock collection target numbers with genetic guidelines.	R
	7.6. Consistency of mating protocols with genetic guidelines.	R
8. Progeny reared in hatchery are healthy and survive upon release	8.1. Survival rates through different developmental stages (hatching success, egg to swim-up, and swim-up to release).	B
	8.2. Feeding efficiency and growth rates relative to projected biomass.	B
	8.3. Incidence of infectious pathogens.	R
	8.4. Size, weight, and age of fish released.	B
9. Hatchery fish contribute to natural production.	9.1. Comparison and similarity of released fry to natural fry in life history traits: incubation survival rate, development, morphology, size, outmigration and smoltification characteristics, release timing and location (gravel vs incubators).	B
	9.2. Post-release survival rates.	B
	9.3. Annual egg-to-smolt and smolt-to-adult survival rates and trends in productivity for hatchery and wild fish.	B
	9.4. Number and trend of natural origin recruits attributable to program.	B
Diversity		
10. Current and "historic" genetic spawning aggregation structure of anadromous sockeye salmon and resident kokanee.	10.1. Genetic similarity of present and recent past samples from Lake Ozette sockeye and kokanee salmon (Attachment 2; Section 12).	B
	10.2. Regular genetic surveys of beach and tributary spawning aggregations.	B
	10.3. Regular analysis of -spawning aggregations for genetic patterns and trends.	B
11. Conservation of ecological and genetic characteristics of existing beach spawners.	11.1. Patterns of life history variation (age composition, fecundity, body size, sex ratio, juvenile and adult migration timing, and locations of spawning areas, rearing behavior, feeding behavior, and straying).	B
	11.2. Introgression of kokanee alleles in beach spawners less than 1% or natural levels based on DNA markers.	R
	11.3. Genetic effective population size, based on estimates from genetic data or demographic data (wild and hatchery abundance, age structure, sex ratios, and mating strategies).	R

Diversity (continued)		
12. Reestablishment of stream-spawning life history types in all suitable tributaries.	12.1. Proportion or number of natural origin recruits and NOR spawner replacement rates in Umbrella Creek and Big River.	B
	12.2. Proportion or number of wild and hatchery origin fish used for brood stock in tributary reintroduction programs; NOR and hatchery survival rates to spawning.	B
13. Reestablishment of sockeye salmon to suitable habitat of unused beaches along the shoreline of Lake Ozette.	13.1. Number of sockeye salmon using suitable but currently vacant beaches in Lake Ozette.	B
Spawning Aggregation Spatial Structure		
14. Reestablishment of multiple spawning subpopulations of sockeye salmon throughout the Lake Ozette watershed.	14.1. Number of tributary spawning areas with tributary spawning sockeye salmon.	B
	14.2. Number of beaches with sockeye salmon spawning using hydroacoustic and scuba surveys combined with sonic tagging.	B
	14.3. Changes in morphological or life history characteristics indicating local adaptation.	B
Community Aquatic Ecology		
15. Conservation of the characteristics of native fish spawning aggregations in the Basin.	15.1. Native species richness and diversity.	B
	15.2. Species diversity and abundance of introduced species.	R
Adaptive Management		
16. Integration of scientific learning into decision making.	16.1. Monitoring plan developed and implemented.	B
	16.2. Number of research projects funded.	B
	16.3. Annual publication of analyses from monitoring and research.	B
	16.4. Decision-making framework established.	B
Treaty Rights		
17. Reestablishment of tribal fisheries	17.1. Numbers, pounds, age, size of fish caught.	B
	17.2. Number of days of fishing allowed.	B
	17.3. Number of tribal fishers and families fishing.	B

1.9) Expected size of program:

Specify expected releases, adult fish harvested, and escapement goals. For existing program, provide additional historic data for three generations, or for the number of years of available and dependable information

Brood stock collections and releases for the past 14 years are shown below in Table 3. Detailed rationale for brood stock collection goals and methods are explained in Section 6.

Table 3. Numbers of adult Lake Ozette sockeye collected for brood stock and location, number, and life stage of progeny released over a 14-year period.

Brood Year	No. Adults Collected		Release Year	No. Progeny Released	Life History Stage Released	Location of Release
	M	F				
1986	19	17	1987	12,400	Fry	Umbrella Cr. / Lake Ozette
1987	73	55	1988	133,300	Fry	Lake Ozette
1988	86	108	1989	199,767	Fry	Umbrella Cr. /L. Ozette
1989	0	0	1990	N/A	N/A	N/A
1990	11	7	1991	9,504	Fry	Lake Ozette
1991	63	67	1992	36,703	Fry	Umbrella Cr. / Lake Ozette
1992	59	50	1993	0	N/A	N/A
1993	17	15	1994	28,171	Fry	Lake Ozette
1994	28	26	1995	44,432	Fry	Lake Ozette
1995	56	38	1996	45,220	Fry	Umbrella Cr.
1996	93	107	1997	266,295	21% eyed egg, 79% Fry	Crooked Cr.(egg) / Umbrella Cr.(fry)
1997	98	107	1998	187,756	7% egg, 93% Fry	Crooked Cr.(egg) / Umbrella Cr.(fry)
1998	52	36	1999	69,328	60% eyed egg, 40% Fry	Crooked Cr.(egg) / Umbrella Cr.(fry)/ L. Ozette (egg)
1999	17	12	2000	36,660	100% eyed eggs	50 % Olsen's Beach (egg)/ 50% Big River (egg)

A total of 29 adult sockeye were collected from Olsen's Beach in 1999 comprised of 12 females and 17 males. One male died during transport and one jack was collected for genetic analysis, but was not spawned. The remaining 12 females and 15 males were spawned. Approximately 36,000 eyed eggs were used to study survival to hatching in incubators to demonstrate method and determine replicated survival analysis in two experiments in 2000. The first experiment consisted of 17,575 eyed eggs used to evaluate incubation survival in Big River (400 eggs per replicate; 44 replicates) and 17,310 eyed eggs used to evaluate incubation survival in Lake Ozette (400 eggs per replicate; 42 replicates). Groups of five incubators were bolted together (each incubator contained 400 eggs partitioned among 200 compartments at 2 eggs per cell), and planted in 9 blocks (2000 eggs total per block).

A total of 1,333 adult Lake Ozette sockeye were collected for brood stock over a 13- year period from 1986 to 1998. An additional 29 adults, collected in 1999, bring the total collected to date to 1,362; but this last collection was not included in the following observations which were made prior to the 1999 collection. Of the 1,333 adults collected through 1998, 633 were females and 655 were males. Sex was not determined for 45 adults in 1991. Female collections from 1986 to 1998 have ranged from 0 to 108 with mean and SEM of 49 ± 11 among collection years. Male collections from 1986 to 1998 have ranged from 0 to 98 with mean and SEM of 50 ± 9 among collection years. Total collections from 1986 to 1998 have ranged from 0 to 205 adults with an overall average of 103 brood stock collected per year and mean and SEM of 99 ± 20, n = 13, among collection years.

Fry releases from 1987 to 2000 (progeny of brood years 1986 to 1999; with the Yr-2000 release number projected) totaled 974,584 fry, and ranged from 0 to 210,373 with a grand mean and SEM of 74,968 ± 21,073, n = 13, among these release years. Egg plants from 1997 to 2000 (from brood years 1996 to 1999; with the 2000 plants being projected) totaled 136,456 eggs overall, ranging from 13,143 to 55,922 eggs with mean and SEM of 34,114 ± 9,312, n = 13, among these four egg plant years. Total releases from 1987 to 2000 (Yr-2000 releases being projected) were 1,111,039 overall, ranging from 0 to 266,295, with a grand mean and SEM of 85,465 ± 23,508, n = 13, among release years.

No adult sockeye have been taken for harvest in the past 16 years (see Section 2.3 for more details on past harvests). Numerical recovery and escapement goals for beaches and tributaries and spawner density goals within sub-habitats are under development by the Makah Tribe, the Technical Review Team, and by Lake Ozette Technical Work Groups, as more is learned about the productivity of these specific spawning habitats.

1.10) Date program started or is expected to start:

August 2000.

History: The egg source for the Umbrella Creek Hatchery for brood year 1982, its first year of operation, was from the Quinault River (WRIA 21.0398). The progeny from this year only were hatched at Umbrella Creek and transferred to a net pen for additional rearing in Lake Ozette until their June 1983 release. From 1983 to 1999, all eggs collected were from Olsen's and/or Allen's beach spawners, the two major spawning beaches in the lake. Beginnning in 2000, the source for future brood stock for tributary releases will be from returns to lake tributaries, primarily Umbrella Creek. In 2000 through 2003, we propose to remove any adult sockeye that can be captured from Crooked Creek before they spawn (because reintroduction to this stream has been discontinued and because removing these fish before spawning will reduce the potential for hybridization with kokanee). Additionally, this will foster more rapid colonization of natural spawners in Umbrella Creek by reducing removals of natural spawners. The egg source for all future experimentation or supplementation in the lake will come from appropriate beach spawners.

In 1983 and 1985, the progeny were reared at the Umbrella Creek Hatchery and released at river mile 0.8 in Umbrella Creek, at the Hoko-Ozette road bridge. In brood year 1984, no eggs were obtained, and there was no release. Between BY 1986 and BY 1994 inclusive, the progeny were reared at the Umbrella Creek Hatchery and later transferred for a boat release directly into the lake as recommended by the previous Lake Ozette Sockeye Steering Committee (Jacobs *et al*. 1996). All fry and fingerlings since brood year 1995 have been released directly from the Umbrella Creek Hatchery. Egg plants are slated for Big River and lake beaches to allow for imprinting to occur at release sites other than Umbrella Creek.

Capture and holding methods have also evolved. Very green brood stock were captured at the weir in 1988 and in 1991 and held in the lake in cages and net pens, respectively, over the summer months. Both lake holding methods caused significant mortality and were discontinued. Mortality resulted from disease due primarily to warm water temperatures in the lake and from trauma and secondary infections from injuries caused by the migratory adults attempting to escape their enclosures. Seines were employed to capture brood stock from the lake but their use was discontinued because they had a propensity to become snagged on woody debris causing mortalities. Immature green fish and ripe fish are not captured any more and the collection targets green fish just beginning to ovulate to improve holding survival (immature fish were not successfully held) and to improve egg quality and survival (egg quality in actively spawning fish was not consistent due to over-ripeness).

1.11) Expected duration of program:

12 years or three generations per release site with this current HGMP to conclude in 2012, predicated on the successful re-establishment of each of the four year classes required to provide viable, naturally-spawning, fully-seeded aggregations in the release areas. After 12 years, the program will be reevaluated. If the program is successful in establishing a self-sustaining sockeye run which meets determined escapement goals for the basin and for Big River, Umbrella Creek, and the lake spawning beaches (if deemed appropriate), culminating in sustainable fisheries, it will be terminated. If the program is determined to not be effective, it will be terminated. If the program is succeeding and is expected to accomplish, but has not fully accomplished, the goals and performance standards, the continuance of specific components of the program will be proposed and reevaluated. Similarly, if aspects of the program are not meeting goals or standards, but alternative adaptive management measures are available that are likely to achieve goals and standards providing a net benefit to the ESU, program elements may be changed and continued upon evaluation and reassessment.

1.12) Watersheds targeted by program:

Umbrella Creek (WRIA 20.0052),
Big River (WRIA 20.0058),
Lake Ozette (WRIA 20.0046)

The region targeted by this Hatchery and Genetic Management Plan is the Lake Ozette watershed, near the northwestern tip of the Olympic Peninsula in Washington State. The 88.4-square-mile Ozette Basin is located within the Makah Tribe's Usual and Accustomed Area (U&A). Lake Ozette and the lands immediately surrounding it fall within Olympic National Park. With the exception of the west shore of the lake, the park boundary is a short distance from the shore, and is bordered primarily by industrial timberlands, which comprise the majority of the Basin area. On the western shore of the lake, the park boundary continues westward to the coast, one to two miles distant.

The Ozette Reservation, which is an historically important fishing and whaling settlement of the Makah Tribe, is located on 800 acres which the Ozette River crosses before it drains into the Pacific Ocean from Lake Ozette. Umbrella Creek and Big River, the two main drainages in the Basin, are located primarily eastward of the lake and for the most part on industrial timberlands and possess significant fish-bearing tributary habitat. In addition to lake reintroduction and supplementation, tributaries slated for reintroduction and supplementation include Umbrella Creek and Big River. Tributaries in the Ozette Watershed fall within USGS hydrologic unit number 12043150, and within Water Resource Inventory Area (WRIA) 20.

SECTION 2. RELATIONSHIP OF PROGRAM TO OTHER MANAGEMENT OBJECTIVES

2.1) Existing agreements:

List all existing cooperative agreements, memoranda of understanding, memoranda of agreement, or other management plans or court orders under which program operates. Indicate whether this HGMP is consistent with these plans and commitments, and explain any discrepancies.

This Lake Ozette Sockeye Hatchery and Genetic Management Plan is part of the overall Lake Ozette Sockeye Recovery Plan under development by the co-managers for this ESU, consisting of hatchery and habitat components which include monitoring, research, and associated habitat protection, assessment and restoration to compliment artificial production. Management of the Makah National Fish Hatchery is addressed to a certain degree within the 1994 Cooperative Agreement and in the 1975 Lease Agreement beyween the U.S. Fish and Wildlife Service and the Makah Tribe. There are no other existing MOU's, court orders, or other management plans under which this program operates. This plan will continue to be periodically reviewed by Technical Work Groups under the Lake Ozette Sockeye Steering Committee and by NMFS. This plan follows general guidelines for integrated recovery plans as described by the Comprehensive Coho Artificial Production Plan (CCAP) which are to prevent extinction, increase natural origin recruits, employ reintroduction, and conduct research.

The production objectives for this program optimize productivity while minimizing adverse ecological and genetic risks.

2.2) Status of natural populations in target area:

For "integrated" programs (i.e., supplementation programs or other programs that involve close integration with a specific natural population), identify the natural population targeted for integration.

The natural spawning aggregations targeted for integration by this supplementation program for all tributary plants will be adult sockeye salmon returning to Umbrella Creek beginning with the 2000 adult return. From 2000 through 2003, we also propose to remove any adult sockeye that can be captured from Crooked Creek before they spawn to reduce the potential for hybridization with kokanee and to foster more rapid colonization of natural spawners in Umbrella Creek by reducing removals of natural spawners. Pending research findings, the source of future reintroduction and/or supplementation efforts in the lake will be natural beach spawning aggregations of adult Lake Ozette sockeye salmon, which were the source for all brood stock prior to 2000. Culture and resulting supplementation of the existing individual beach spawning aggregations in the future will continue to require segregation during holding, spawning, and rearing. No brood stock have been collected from Allen's Beach for supplementation since 1997. Beginning in 2000, no brood stock will be collected from any lake beaches other than small numbers strictly for experimental purposes to identify limiting factors during egg incubation in the lake. Lake supplementation and/or reintroduction will occur only after sufficient research has been conducted to establish that there are significant expected benefits relative to minimal risk of harm. An incremental approach will be taken if and when supplementation of lake beaches is determined to be beneficial to survival and recovery of the Lake Ozette sockeye ESU.

If and when reintroduction occurs in unutilized or under-utilized beach spawning areas, either Olsen’s or Allen’s Beach brood stock may be used, depending on results of genetic analyses, proximity to the target planting beach, abundance and trend, spatial structure, and diversity goals, habitat utilization, and the outcome of research on reproductive success and limiting factors analyses. In tributary sub-habitats, tributary spawners will replace lake stock, beginning in 2000, as the source of brood stock for tributary reintroduction and supplementation, as described in Sections 5 and 6.

2.2.1) Geographic and temporal spawning distribution:

At present, Lake Ozette sockeye are known to spawn in two locations in Lake Ozette, and in two lake tributaries, Umbrella Creek and Big River. In Lake Ozette, the two known beach spawning aggregations occupy Olsen’s Beach and Allen’s Bay Beach, which are on the eastern and western sides of the southern end of the Lake (Figure 2). Umbrella Creek and Big River both enter Lake Ozette on the northeastern side of the lake (Figures 2 and 2A). Maps of major streams, locations of fish hatcheries, existing roads, and land ownership are also included in Figures 2A and 2B.

Adults migrate into Lake Ozette from the Ozette River from April through mid-August, and spawn in the lake and tributaries primarily from early November into January. Since spawning on lake beaches has been observed as early as November 2, it is likely that low numbers may spawn as early as late-October. Likewise, there appear to be low numbers of fish that are not ready to spawn on lake beaches as late as February. Capture attempts made in January 1999 by MFM did not find any late spawners, but after multiple capture attempts were made from December through February in 2000 to find late spawners, MFM captured a single green female in February of 2000 from Allen's Beach. Sonic tagging and tracking of returning adults combined with hydroacoustic, scuba, and possibly net surveys are planned beginning in the Yr-2000 to learn more about adult temporal spawning distribution, abundance, and behavior in the lake.

In 1998 and in previous years, no methodical lakeshore surveys were conducted except for those reported from 1977 through 1980 (Dlugokenski *et al.*1981). In the fall of 1999, the presence of lake shore spawners and redd-building activity was first observed on Olsen's Beach and on Allen's Bay beach in early November. Large numbers of adults were also observed schooling and jumping offshore from this beach in early-November of 1999. Jacobs *et al*. (1996) reported that spawning in the lake occurs from November through March each year. In 1999, minimal spawning activity was observed on Allen's Beach in early November, very few spawning adults were observed, and very few carcasses were recovered for genetic sampling, although no specific efforts were made to do so beyond the spawner surveys. In the future, extensive efforts will be directed specifically to recover carcasses from the beaches for genetic sampling, and to record the incidence of any hatchery fish through analyses of otolith and fin clip marking prevalences.

In Umbrella Creek, spawning occurs beginning in early-November through January each year with peak spawning occurring in early December each year (MFM, unpublished spawn survey data). Surveys were conducted in 1998, 1999, and 2000 by MFM in Big River, Boe, Solberg, Trout, Umbrella, W.F. Umbrella, Crooked, N.F. Crooked, and S.F. Crooked Creeks. Adult sockeye were observed spawning in Umbrella Creek from November through early-January in 1998 with a peak count of approximately 96 adults and a measured peak spawning density of 42 adults per mile surveyed, despite missing the peak spawning period due to poor visibility.

The first recently documented sockeye spawning in Big River were observed from early to late December of 1998 spawning in close proximity to, and downstream from , the mouth of Solberg Creek. No sockeye spawning aggregations have been documented in scientific literature in Big River prior to 1998 and none were observed in the 1999/2000 season. The origin of the 1998 fish is unknown because sockeye were never planted in Big River prior to year 2000 egg plants.

Adult sockeye were observed spawning in Umbrella Creek from October through early January in 1999 with a peak count of approximately 312 adults and a measured peak spawning density of 138 adults per mile surveyed (Figure 3). Surveys conducted by Dlugokenski *et al.* (1981) in Umbrella Creek in return year 1978 visited some of the same areas as in recent surveys, but did not find any adult sockeye spawning nor were sockeye seen in Big River. These surveys did find sockeye north of the mouth of Umbrella Creek (Umbrella Beach), where no sockeye have been seen since, although surveys have been sparse at best.

The surveys of Dlugokenski *et al.* (1981) also identified sockeye at Olsen's and Allen's Beaches. Interestingly, these surveys identified distinct run timing at all three lake shore sites. This is something that has not been observed in the last few years. Dlugokenski *et al.* (1981) identified the east shore spawning to peak on 12/20/78, while west shore activity was observed to be most active on 1/14/79. Adults on Umbrella Beach were first observed after the peak of the run, so peak timing there could not be determined by Dlugokenski *et al.* (1981). In recent years, no outlet spawners nor any beach spawners have been observed on Umbrella Beach. Spawning on Allen's and Olsen's Beaches has occurred at the same approximate time with the majority of spawning initiated in early November, peaking in late-November to mid-December and largely completed by late-December on both beaches.

Little was known about the historic abundance, timing, or geographic distribution of Ozette sockeye before increased exploitation and coincident clear-cut timber harvest of much of the Basin drastically altered both habitat and population characteristics. We have only the oral histories passed on by Tribal elders, and anecdotal information from local residents. These are by no means complete, and often unclear as to time of year or specific location.

Recent observations of tributary spawners in Big River and Umbrella Creek and historic accounts of the presence of tributary spawning aggregations by Makah Tribal elders and settlers in the Ozette Basin are supported by general knowledge of sockeye salmon life history. Most sockeye salmon populations have tributary spawning components with exclusive lake spawning populations being very rare (Forester 1968; Brannon personal communication). Most of the production in those populations that have beach spawning components (i.e. Lake Iliamna, AK) is derived from tributary spawning components (Brannon personal communication). Very few sockeye populations derive their primary production from lake spawners (i.e. Cultis Lake, B.C.; although some tributary spawning occurs even in this system) and typically do so only when they lack tributary spawning habitat (Brannon personal communication).

Recent recommendations and observations of a blue ribbon panel of 25 biologists and fisheries experts that evaluated factors for decline of Lake Ozette sockeye (Jacobs *et al*. 1996), stated that, "The most common presumption is that sockeye salmon once used tributaries of Lake Ozette for spawning." The panel concluded that the loss of tributary populations was a plausible contributing factor for decline of Lake Ozette sockeye. Lestelle *In* Jacobs *et al.* (1996) surmised that it would be important to reestablish tributary spawners due to his concern over the loss of life history diversity and the demise of certain life history types. He noted that the sharp decline in Ozette coho tributary spawning populations occurred during the same period as the decline of Ozette sockeye, as possibly evidenced by catch reductions occurring in both species during the same period. During this time, severe habitat degradation from logging, compounded with large fishery harvests, may have contributed cumulatively to the extinction of tributary spawning sockeye populations in the Basin. Large declines in the abundance of Lake Quinault sockeye during this period (1940's to 1950's) were also cited by Lestelle *In* Jacobs *et al.* (1996). In addition to habitat destruction and harvest during this period, Gilbertson *et al*. (1981) as cited in Jacobs *et al.* (1996) documented unusually large floods on the Washington coast in the 1940's and 1950's which was also documented in Houston (1983) from 1911 to 1978. It would be logical to conclude that this combination of extreme environmental perturbations may have had wholesale degratory effects on Ozette Basin watersheds, resulting in the extinction of tributary spawning aggregations.

The loss of tributary spawning aggregations has been cited as one of the primary factors for decline of Lake Ozette sockeye in most of the literature (Bortleson and Dion 1979; Dlugokenski *et al.* 1981; Blum 1988; LaRiviere *et al.* 1991; Jacobs *et al.* 1996; MFM 2000).

Dlugokenski *et al.* (1981) cited personal communications in 1978 from Pete Ward (a fish biologist with the Makah), Emil Person (an Ozette Basin resident), and J. Ayerst (a fish biologist with Washington Department of Wildlife) as evidence that sockeye historically utilized Lake Ozette tributaries. Mr. Person currently continues to homestead on Big River and still recalls observing sockeye in Big River and in Umbrella Creek (Mike Crewson personal communication). John Cowan, another homesteader still residing in the Basin, recalled seeing eight adult sockeye salmon in a hole near a bridge on Big River at about river kilometer 11.6 in late May or June on one occasion only in the mid 1920's, the only occasion that he was there at that time of year. He recalled that some of the fish were green only, whereas others were beginning to turn red (Ned Currence, Makah Habitat Biologist, personal communication). Other settlers that remember seeing sockeye in Ozette tributaries that are still alive include Albert Boe, James E. Wesseler, Jim Palmquist, Palmer J. Trettevick, and William Parker Sr. (Mike Crewson, Makah Fisheries Management, personal communication). Some of these accounts were published I*n* Jacobs *et al*. (1996).

In 1941 interviews between the U.S. Associate Attorney, Edward G. Swindell Jr., with Makah Tribal elders over ancient fishing locations, there are numerous accounts of fishing for sockeye. Matilda McCarty (age 48 in 1941) fished Ozette for blue back salmon, and recalled that, “They used to go up the streams and spear the salmon.” Other Makah Tribal members who recollect fishing for sockeye at Ozette included Lea Parker, John Hottoway Sr., and Arther Johnson (age 67 in 1941).

Other literature surmised the presence or absence of tributary spawners but never looked for any. Phinney and Bucknell (1975) stated that sockeye spawning in the Basin included the Ozette River, Coal Creek, Umbrella Creek, Big River, Crooked Creek mainstem, N.F. and S.F., and in Quinn Creek; however, the authors never actually surveyed these streams (Lloyd Phinney personal communication, 1999). Kimmerich (1945) presumed that there was no evidence that sockeye spawned in the tributaries to Lake Ozette but the author never looked for spawners. This paper was published 20 years after the work was conducted. The work occurred during the summer and not during the fall and winter when tributary spawning occurs. In an unpublished MFM report, LaRiviere reported that approximately one dozen adult sockeye were observed by MFM surveyors in the Ozette River in spawning coloration in August (MFM FY 1983 unpublished report). These river spawners, never before documented in the system, would have comprised yet another spawning aggregation; however, upon recent scrutiny of field notes during this period, it was concluded that these fish were adult coho and not sockeye (Mark LaRiviere personal communication, 1999).

Recently, a small spawning aggregation of adult sockeye was observed in Big River. In November and December of 1998, approximately 30 adult sockeye salmon were observed spawning in Big River from RM 4.4 to RM 5.0 in November and December of 1998 (MFM unpublished data; ONP unpublished data).

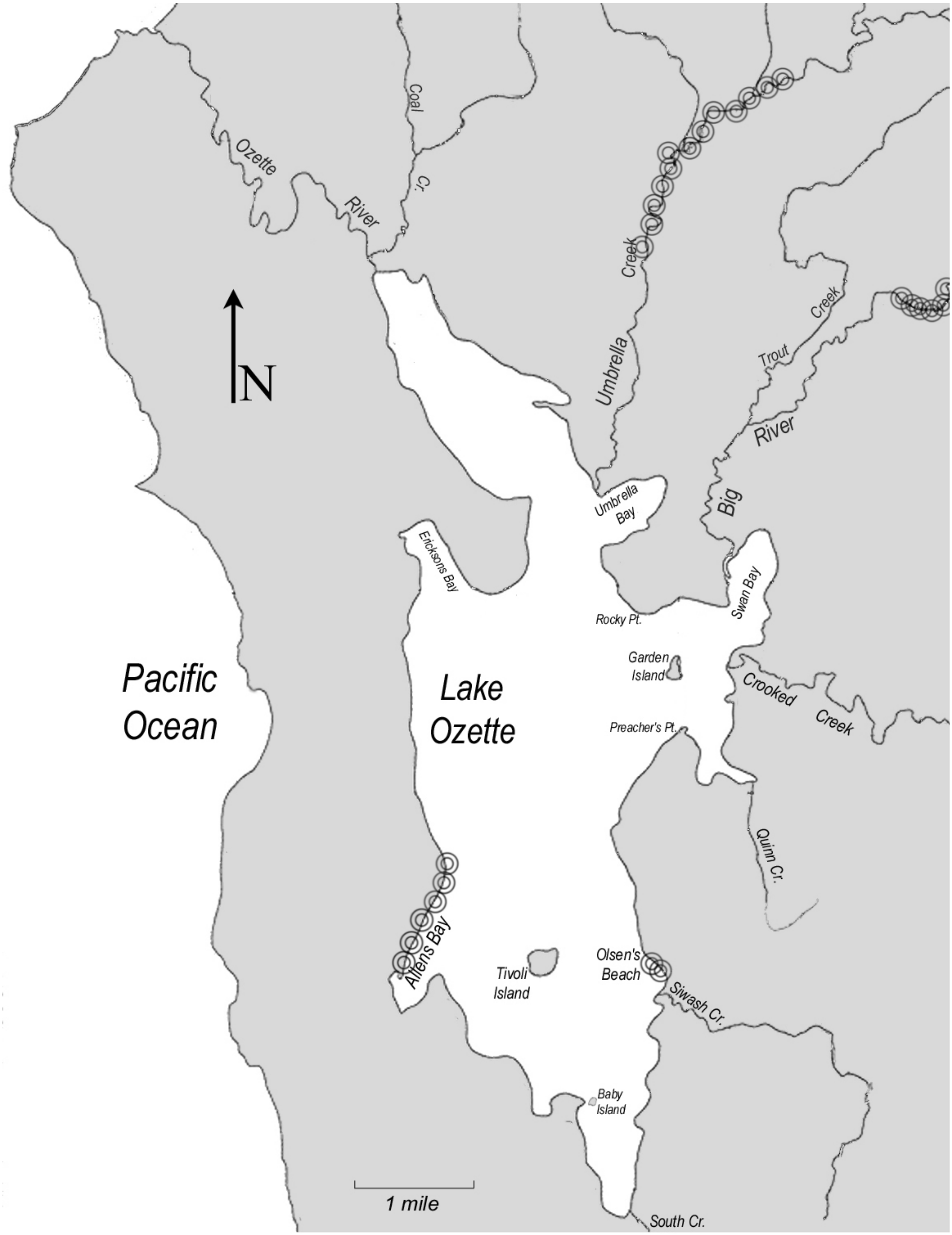
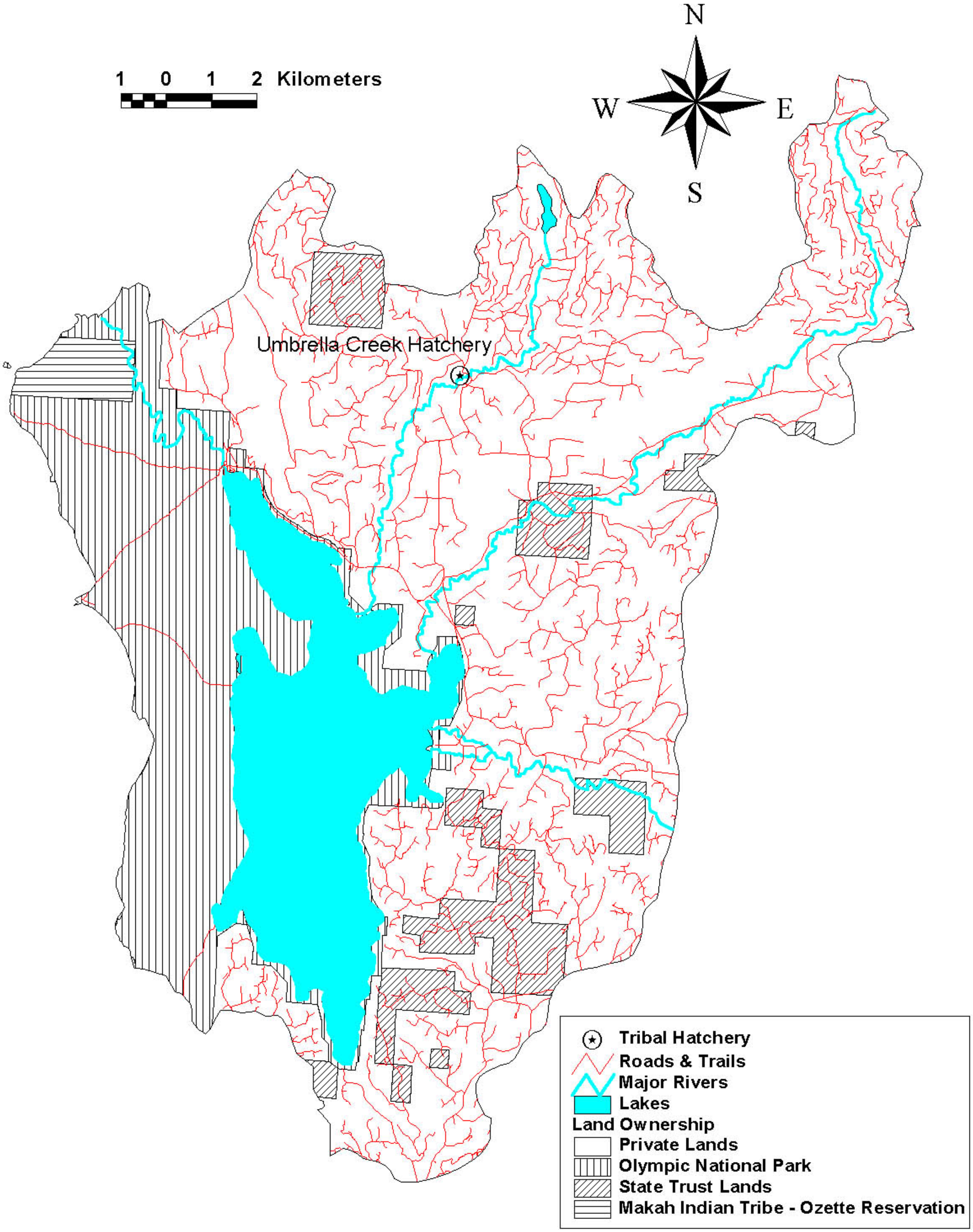
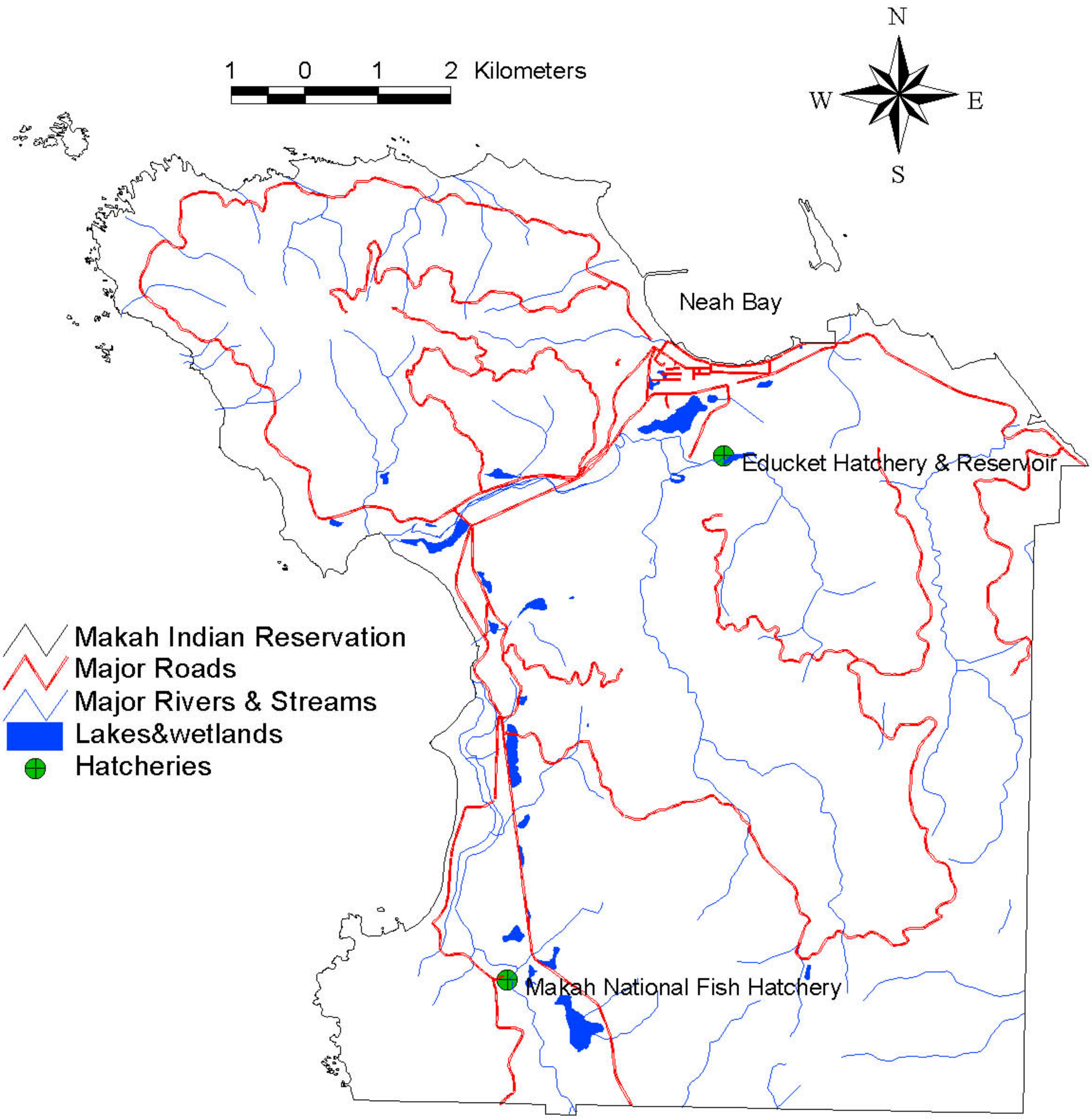


Figure 2. Map of Lake Ozette and tributaries.



2A. Map of the Ozette watershed depicting land ownership, existing roads, major streams, and location of the Umbrella Creek Hatchery .



2B. Map of the Makah Reservation depicting locations of the Makah National Fish Hatchery and the Makah Tribal Educket Fish Hatchery quarantine isoincubation buildings.

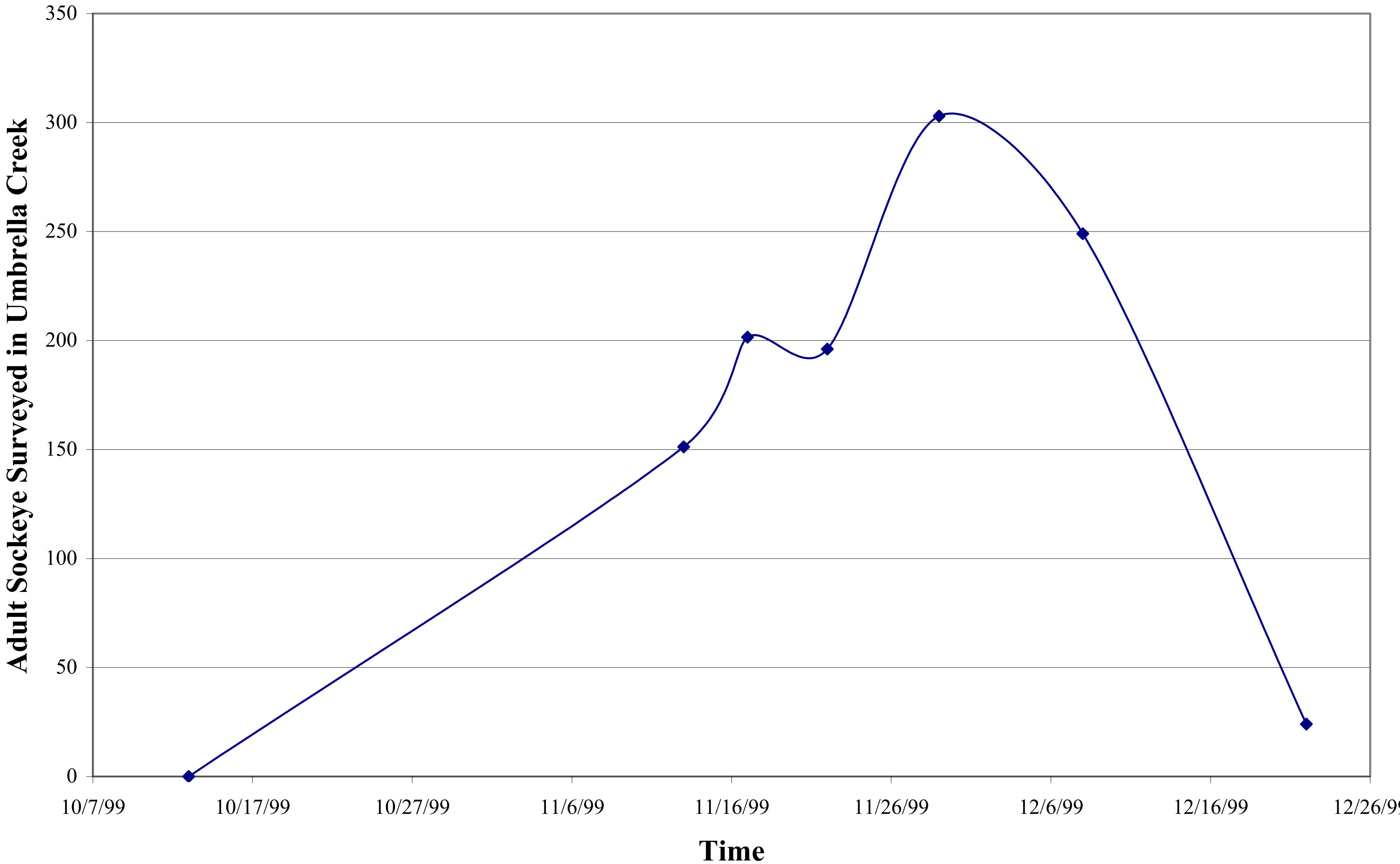


Figure 3. 1999 adjusted adult sockeye counts for Umbrella Creek from RM 2.52 to 4.78.

2.2.2) Annual spawning abundance for as many years as available:

The historical abundance of Ozette sockeye is poorly documented. In the first study of lake escapement of Ozette sockeye prior to the late 1970's, Kemmerich (1945) estimated the run size entering the lake at a level of several thousand fish. These counts are assumed to have been conducted upstream from fisheries in or near to the Ozette River. Verbal reports from fish buyers of sockeye harvested by the Makah Tribe purportedly ranged from 14,556 to 17,638 fish during a three year period from 1949 to 1951. These catches were assumed to be from the Ozette River as reported by Dlugokenski *et al.* (1981) and later in Jacobs *et al.* (1996); however, there were and are no written fish tickets or other records of these harvests (Jeff Haymes, WDFW, personal communication).

While catches reported from the Makah Tribe declined from several thousand sockeye to less than 100 fish within the following 20 years, these three large catches appear disproportionately large relative to any other years recorded (Table 4). During this same period, large catches of Lake Quinault sockeye averaging approximately 120,000 fish, were reported from the Quinault River, located to the south of the Ozette River, as reported by Ward *et al.* (1976) and Gilbertson (1981) In Jacobs *et al.* (1996). Makah Fisheries Management believes that it is not reliable to use these verbal catch reports from fish buyers as a measure of historic abundance. Dlugokenski *et al.* (1981), reported that, "catch data from 1948 through 1972 is extremely unreliable and is presented here primarily to illustrate a general decline in harvest." Any application of these reports to the determination of numerical recovery goals will continue to be very questionable.

Due to the decline in catch and apparent abundance of Lake Ozette sockeye, a joint study between the Makah Tribe, the U.S. Geological Survey, and the U.S. Fish and Wildlife Service was initiated at the request of the Makah Tribe in 1976 (Dlugokenski *et al.* 1981). This study was the next documented record of Lake Ozette sockeye abundance following that of Kemmerich (1945) which was conducted in the 1920's. Adult sockeye enumeration was accomplished by recording passage from an observation platform above an illuminated counting board placed on a net weir weighted to the bottom of the Ozette River below the lake outlet with a lead line and chain. Counts were performed primarily from dusk to dawn with a complete 24-hour count only performed biweekly; however, the investigators did not observe any daytime migrants and assumed there were none (Dlugokenski *et al.* 1981). It is presumed that the weir was left open during the daytime. Upstream migrating adult sockeye were known to burrow under the net and on other occasions, the net was unmanned during observation periods (Rob Snyder, personal communication).

Dlugokenski *et al.* (1981) claimed that, "the escapements from 1977 to 1979 were based on counting every fish passing our weir between May 9 to August 6." Makah Fisheries Management currently retains copies of the original weir data from 1978 reported in Dlugokenski *et al.* (1981). A recent analysis of the weir counts makes it highly questionable whether every fish passing the weir was counted (MFM *in preparation*). The first daily counts recorded in 1978 can be seen to rise abruptly from 0 to 31 fish within consecutive days in mid-May and then dropped to zero for more than two weeks, remained low until the first week of June, when they suddenly rose to single day counts of 50 fish. Counts remained relatively high through June 24, 1978, and a model was subsequently developed based on the author's presumption that 63% of the run moved into the lake between June 5 to June 24.

The model developed by Dlugokenski *et al.* (1981) estimated the 1980 lake escapement using the following equation:

$N = n*q$,

where:

N = total run size estimate,

n = sample size,

p = average proportion of run passing the weir during a given period from
1977 through 1979 (June 5 – 24)

q = 1/p.

In order for this equation to yield reliable estimates of abundance, at least five assumptions must be true: 1) q is normally distributed among years, 2) no fish entered the lake during daytime hours, 3) all fish that entered the lake passed through the weir opening, 4) visual observers counted all fish that passed through the opening, and 5) all fish entering the lake were enumerated between 1977 and 1979.

During 1998 and 1999, MFM conducted detailed adult sockeye enumeration, employing a weir with counting board, similar to Dlugokenski *et al.* (1981). In addition to visual observers, an underwater video camera was mounted in front of the weir opening and operated 24 hours per day for a portion of 1998 and for all of the 1999 adult migration into Lake Ozette. With regard to the above assumptions, it was found that:

1) q is not normally distributed among years,
2) up to 36% (maximum bi-weekly average) of the fish entered the lake during daylight hours,
3) some fish were known to have passed under the weir and bypassed the opening,
4) visual observers appeared to only count approximately 70% of the fish that passed through the weir opening (MFM *in preparation*), and
5) as a result of these findings, it is highly likely that all of the fish were not enumerated as claimed in by Dlugokenski *et al.* (1981). We assume here that at least some of the assumptions that were false in 1998 and 1999 were also false in 1980 when the model was applied by these authors to estimate lake escapement.

A more detailed examination of the above assumptions has recently revealed that:

1) 50% and 33% of the run entered the lake between June 5 to June 24 in 1998 and 1999, respectively (MFM, *in preparation*), in contrast to the three-year mean of 63% previously reported from 1977 to 1979. Even when looking at the source data of Dlugokenski *et al.* (1981), there appears to be substantial inter-annual variation in run timing among the years 1977 to 1979, resembling the variation recently observed between 1998 and 1999. A detailed analysis of inter-annual run timing variation was not possible for return years 1977 through 1979 because portions of the 1977 and 1979 data are missing. These observations of different run timing in Ozette sockeye and variations observed in inter-annual run timing in other sockeye populations suggest that applying a fixed proportion of the Ozette run size to a certain time window is problematic. Inter-annual variations in run timing have been known to vary between one to four weeks in Fraser River sockeye (Tim Tynan, NMFS, personal communication).

2) Based on 24-hour camera counts, 11% to 27% (estimated annual mean) of the adult sockeye were found to enter the lake during daylight hours (0700 to 2200 hr) in 1998 and 1999. It is not surprising that this significant daytime migration contrasts with the supposition by Dlugokenski *et al.* (1981) that there were no daytime migrants, because the net weir was left unmanned and presumably open. A further examination of run timing past the weir in 1999 revealed that the rate of daytime passage was skewed toward the beginning of the run. During the early portion of the run, from May 2 to May 15, 1999, 36% of the adult migrants passed the weir during daytime hours; but later in the run, the proportion of daytime migrants gradually dropped to less than 3% by July 11, 1999. It appeared that there was a direct relationship between adult daytime passage and lake level, which corresponds to stream flow (Figure 4). When the rate of daytime passage was regressed against lake level, a highly significant relationship ($p < 0.001$) was observed where 92% of the variation in the percentage of adult sockeye daytime passage was explained by lake level (Figure 5).
3) an unknown but potentially significant number of fish were known to have bypassed the net weir opening when it was deployed from 1977 to 1979 by digging under the bottom of the net which was weighted, but not secured, to the bottom of the riverbed. The weir currently deployed and operated by the Makah Tribe in cooperation with Olympic National Park (ONP) is constructed of metal pickets driven into the riverbed which has minimized the ability of fish to burrow underneath, which occurred with the net weir. Even with metal, a few fish have been observed prying their way between pickets.

Table 4. Numbers of salmon reportedly caught by the Makah Tribe near the mouth of the Ozette River as modified from Jacobs *et al.* (1996).

Year	Chinook	Chum	Coho	Sockeye	Totals	Year	Chinook	Chum	Coho	Sockeye	Totals
1948	491	1,063	1,991	3,850	7,395	1972	0	0	325	346	671
1949	1876	1,339	1,572	17,638	22,425	1973	0	0	0	49	49
1950	1629	1,226	2,407	14,556	19,818	1974	0	0	0	0	0
1951	1213	1,021	1,103	15,074	18,411	1975	33	0	0	0	33
1952	396	682	3,697	3,047	7,822	1976	0	0	0	0	0
1953	431	431	906	2,380	4,148	1977	0	0	0	84	0
1954	823	907	862	2,110	4,702	1978	0	0	0	30*	30
1955	404	806	1,031	1,107	3,348	1979	0	0	0	30	30
1956	241	0	1,149	1,396	2,786	1980	0	0	0	30	30
1957	428	0	1,119	512	2,059	1981	0	0	7	0	7
1958	147	0	721	395	1,263	1982	0	0	15	29	44
1959	0	0	0	682	682	1983	0	0	20	0	20
1960	0	0	0	1,851	1,851	1984	0	0	0	0	0
1961	3	0	281	1,054	1,338	1985	0	2	80	0	82
1962	0	0	385	1,645	2,030	1986	0	0	55	0	55
1963	1	1	263	1,551	1,816	1987	0	0	0	0	0
1964	1	0	350	448	799	1988	0	0	0	0	0
1965	1	0	407	257	665	1989	0	0	0	0	0
1966	0	0	504	405	909	1990	0	0	0	0	0
1967	0	0	272	313	585	1991	0	0	0	0	0
1968	0	0	385	468	853	1992	0	0	0	0	0
1969	0	0	189	295	484	1993	0	0	0	0	0
1970	1	0	296	432	729	1994	0	0	0	0	0
1971	0	0	244	328	572						

* Makah Tribal regulations limited the sockeye harvest to 30 fish for ceremonial purposes.

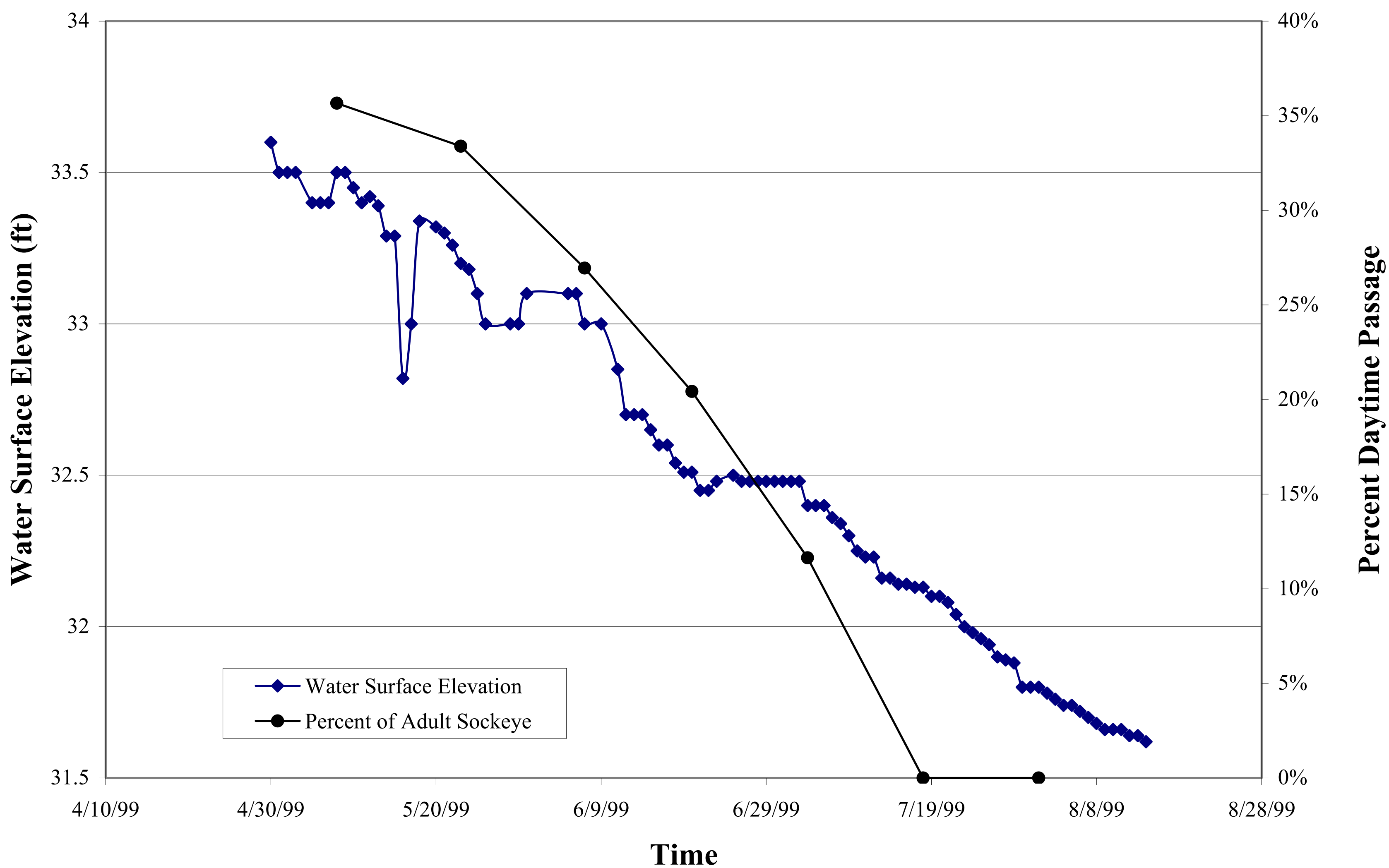


Figure 4. 1999 proportion of adult sockeye passing through the weir during daylight hours (0700 to 2200) and water surface elevation (ft) of Lake Ozette.

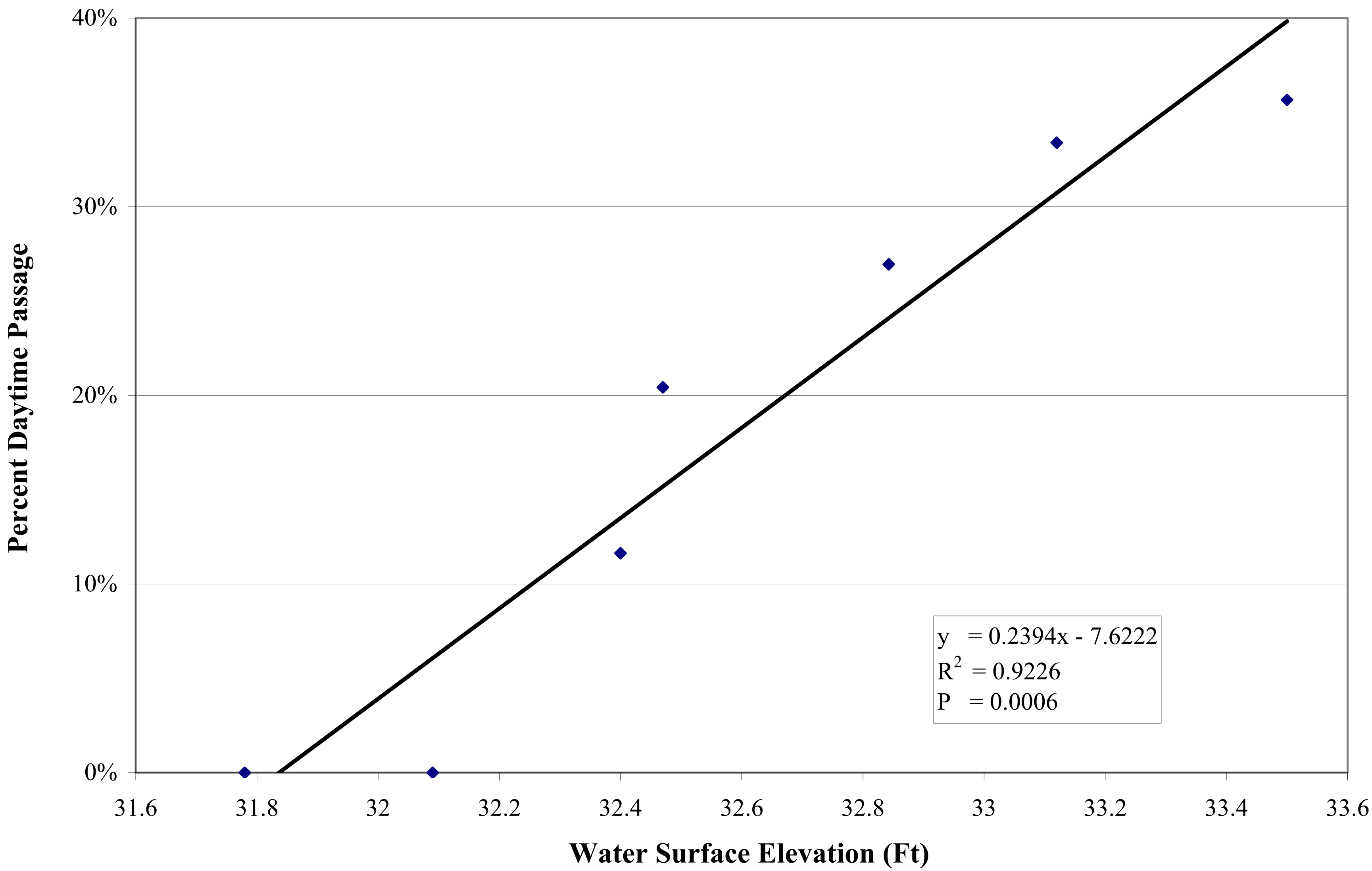


Figure 5. Regression of bi-weekly proportion of adult sockeye daytime migrants (0700 to 2200) against bi-weekly mean water surface elevation of Lake Ozette from May 1 to August 1, 1999.

4) Based on 179 paired observations between the underwater camera and visual observers compared in 1998 and approximately 1,400 paired observations compared in 1999, it was determined that significant proportions of fish, ranging from 36% in 1998 to 18% in 1999, were not counted by the visual observers during their shift from 2200 to 0700. The exact error rate is still being determined and is influenced not only by the inability of the observers to see the fish but also by observers not present while on duty, wind and rain obscuring viewing conditions, inability to discriminate all fish when large schools rapidly passed the viewing area, equipment failures, and distractions (primarily seal, otter, and raccoon activity) when visual observers were present.

5) It is clear that all of the fish were not enumerated between 1977 to 1979 due to the following factors: A) The weir was not operational during the early portion of the run, B) No daylight observations were made by the visual observers, C) Not all fish passed through the weir opening, D) Observers likely could not see all of the fish for the reasons stated above, and E) No expansions were performed for or on missing data.

After the last estimate made by Dlugokenski *et al.* (1981) in 1980 using the above methods, there was no data collected in 1981. This was followed by other methods, which continued to inaccurately estimate the run size. The tendency for the model to under-predict abundance can again be seen in 1982, a year with nearly complete abundance counts, when 2,152 adults were hard-counted but the Dlugokenski model only estimated 1,245 to 1,660, depending on how missing data was applied (MFM *in progress*; Jacobs *et al.* 1996). Also in 1982, only 37% of the run passed through the time window described by the model. No data was available for analyzing the accuracy of run size estimates for return years 1983 and 1986. No data was collected for return years 1985 and 1987. In 1984, the weir was not installed until 6/19/84, which likely missed large numbers of fish since the run is known to begin in late-April and peak by mid-June. However, the 1984 run size estimate was misapplied in subsequent years to calculate run proportions as described below.

Very few weir observations, made only at night, were conducted over the next three years. Annual estimates in 1988, 1989, and 1990 were based on three nights, nine nights, and nine nights of observations, respectively. The run size estimate in 1988 was based on 1982 and 1984 counts. Since only an unknown portion of the run was enumerated in 1984, because the weir wasn't even installed until June 19, the run size estimate from 1984 is not reliable and cannot be applied to calculate subsequent year's run proportions. It is not possible to determine how many adult sockeye were observed on the three days used for the expansion in 1982, because the data is different among three different sources of these data that were compared (MFM electronic database, Blum 1988; LaRiviere *et al.* 1991).

Even considering that only three nights of observation data were available for the calculation in 1988, the run size expansion from this data appears to have been performed incorrectly. As can be seen again in the other expansions described below, the wrong proportion of the run was applied during this three-day window. The total run size reported for 1988 was 2,191; however, accounting for this error would bring the 1988 run size to 3,599. However, with only three days of data collected, it is not possible to estimate the 1988 run size with any accuracy. In 1989, days when no data were collected were misapplied as zero counts (surrounded by very large counts) and subsequently expanded incorrectly using the wrong proportion of the run for the period where data was actually collected. This error produced a run size reported as 538 adults, while a correct interpretation of this data produces a count of 603. Similarly, the total run size reported in 1990 of 263 adults was based on a count of only 175 fish over an 11-day period; however, data was only collected for 9 of the 11 days. This error resulted in an estimate of the 1990 run size of 263, while expansion of this data set should have produced a count of 385 adults.

From 1991 through 1996, the weir was left closed during daytime hours (typically from 5 AM to 11 PM) which encouraged adults to burrow under the pickets and increased mammal predation. During this period, abundance estimates were based on very few days of actual observation, conducted only at night; and errors were made in the resulting expansions of the small, incomplete data sets. In 1992, the total run size expansion was based on 11 nights of observation. While 1,175 total adults were enumerated that year, only 566 were used for the expansion. Due to errors related to using the wrong proportion of the run for the 11-day period where data was actually collected in 1992, which was then applied to the incomplete 1984 data previously described, the estimate reported (2,166) should have been 2,538 adult returns. Also in 1992, an unknown but substantial number of adult sockeye were presumed to have bypassed the weir by burrowing under the pickets (MFM unpublished field notes), from the weir being left open or dismantled occasionally during the day, and from people opening the weir during the day to pass adults upstream without recording their numbers. Large counts were interspersed with extremely low counts during a period when someone was removing weir pickets.

In 1993, the data sheets were lost and only 69 adults were enumerated. In 1994, the expansion was based on only nine days of observation. The small number of adults enumerated (213 fish) was incorrectly expanded (to 498 instead of 585 adults) because the wrong proportion of the run, during the nine-day window, was applied. No data could be found which produced the 1995 estimate of 314. In 1996, total run size was estimated from 12 days of observation (429 fish) and was misapplied in several ways. On one occasion, ten adult sockeye were observed bypassing the weir through a hole (Dave Easton personal communication). Bypassing fish observed outside of the expansion window and other observation days that occurred outside of the expansion window were added to the raw window count which were then incorrectly under-expanded using the wrong proportion of the run for the 12-day period where data was actually collected in 1996. These errors produced an expanded estimate of 1,702 adult sockeye, which should have produced an adult run size estimate in 1996 of 1,778.

Lake Ozette adult sockeye abundance has been significantly underestimated (Table 5; MFM *in progress*) due to inaccurate and inappropriate expansions of weir data, for the reasons previously described, over the past 20 years as reported in Jacobs *et al.* (1996). Recent run size estimates (1998 and 1999) discussed below, using an underwater video camera, provide additional insight to the factors which contributed to underestimating the actual run sizes. Moreover, in excess of 1,600 paired visual and camera observations from 1998 and 1999 were used to determine the proportion of adult sockeye passing the weir and not enumerated by visual observers.

The 1997 run size estimate was then back-calculated by incorporating these recent findings regarding human error and variations in inter-annual run timing. Run size estimates prior to 1997 were not upgraded or adjusted based on our new video camera data mainly because the methods used to enumerate adults in these years were different and also because many of the data sets were either missing, incomplete, or very small. It is extremely important to understand the problems with examining trends among the run size data recorded for Lake Ozette sockeye due to different methods employed on problematic data among years. However, the corrections to run size estimates from 1988 to 1996 that were previously discussed, are shown alongside the original estimates reported in Jacobs *et al*. (1996), with new estimates for 1997, 1998, and 1999 (Table 6).

Table 5. Estimates of lake escapement of adult Lake Ozette sockeye salmon from 1977 to 1999. Modified from Jacobs *et al.* (1996).

Year	No. Adults Observed[1]	Estimated Run Size[2]	Method of Estimate	Citations
1977	920 + 84 adults harvested	1,004	N = n + Harvest	Dlugokenski *et al.* (1981)
1978	890 + 30 harvested	920	N = n + Harvest	Dlugokenski *et al.* (1981)
1979	510 + 30 harvested	540	N = n + Harvest	Dlugokenski *et al.* (1981)
1980	255 + 30 harvested	432	N = nq + Harvest	Dlugokenski *et al.* (1981)
1981	N/D	----	----	----
1982	2,061 + 29 harvested	2,152	N = n + Harvest	Blum 1988; WDFW *et al.* 1994
1983	N/A	350	N = nq	WDFW *et al.* 1994
1984	804	2,170	N = nq	Blum 1988; WDFW *et al.* 1994
1985	N/D	----	----	----
1986	N//A	691	N = nq	LaRiviere 1991; WDFW *et al.* 1994
1987	ND	----	----	----
1988	218 (only 3 days of collection)	2,191	N = nq	LaRiviere 1991
1989	143	538[3]	N = nq	LaRiviere 1991
1990	175	263	N = nq	LaRiviere 1991
1991	377	684	N = nq	Makah Fisheries Mgmt. Dept.
1992	1,175	2,166	N = nq	Makah Fisheries Mgmt. Dept.
1993	69[4]	≤267	N = nq	Makah Fisheries Mgmt. Dept.
1994	N/A	498	N = nq	Makah Fisheries Mgmt. Dept.
1995	N/A	314	N = nq	Makah Fisheries Mgmt. Dept.
1996	429	1,702	N = nq	MFM, *in preparation*
1997	258	1,133[5]	$N = (N_1+N_2)/2$	MFM, *in preparation*
1998	980	1,406[6]	N = R*V+C	MFM, *in preparation*
1999	1,945	2,076[7]	N = R*V+C	MFM, *in preparation*

[1] This column provides a general indication of the intensity of monitoring via a comparison of the number of adults observed versus the estimated run size.

[2] Run size estimate computed using the model developed by Dlugokenski *et al.* (1981): N = nq where:

N = Estimate of total run size,
n = sample size,
p = average proportion of total run that passed the weir during a given period, and
q = 1/p. Data collected throughout the adult run from 1977 to 1979 were used to calculate p for the time period of observation in 1980. Data collected throughout the adult run in 1982 and 1984 were used to calculate p for the time period of observation from 1988 to 1995.

[3] Upon inquiry with Mark LaRiviere, the MFM biologist in 1989, there were not 50 adult sockeye observed in the Ozette River in October, 1989, so this amount was removed from the estimated run size previously reported as 588 (Jacobs et al. 1996).

[4] Field data sheets were lost. Only 69 fish were counted.

[5] For 1997, the run size estimate was produced using the following equation: $N = (N_1+N_2)/2$, where
$N_1 = n * q$,
n = number of adult sockeye that passed the weir from June 10-24 (excluding June 14-16 when no data was collected),
p = mean proportion of total run that passed the weir from June 10-24 (excluding June 14-16 when no data was collected), using adjusted and unadjusted weir counts from 1998 and 1999, and
q = 1/p.

$N_2 = e * n * q$, where

$e = (((TC_{1999} / TV_{1999}) * TC_{1999}) + ((TC_{1998} / TV_{1998}) * TC_{1998})) / (TC_{1999} + TC_{1998})$
TC_{1999} = Total adjusted camera count (5/1/99-8/8/99)
TV_{1999} = Total visual count (5/1/99-8/8/99)
TC_{1998} = Total camera count (6/22/98-7/1/98)
TV_{1998} = Total visual count (6/22/98-7/1/98)
n = number of adult sockeye that passed the weir from June 10-24 (excluding June 14-16 when no data was collected),
p = mean proportion of total run that passed the weir from June 10-24 (excluding June 14-16 when no data was collected), using adjusted and unadjusted weir counts from 1998 and 1999, and
q = 1/p.

---

[6] For 1998, the adjusted run size estimate was produced using the following equation:

$N = R * V_{(\text{may 5, 1998-June 21, 1998})} + C_{(\text{June 22, 1998-August 6, 1998})}$ where,

N = Total adjusted run size
$V_{(\text{may C, 1998-June 21, 1998})}$ = Total visual adult sockeye count from May 5 to June 21, 1998
$C_{(\text{June 22, 1998-August 6, 1998})}$ = Total camera adult sockeye count from June 22 to August 6, 1998
$R = TC_{1998} / TV_{1998}$

TC_{1998} = Total camera count (June 22 to July 1, 1998)
TV_{1998} = Total visual count (June 22 to July 1, 1998)

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[7] For 1999, the adjusted run size estimate accounted for instances of missing data by applying a bi-weekly hourly (fish-per-hour) rate, *BWHR,* to data gaps in the time period, *p,* for which data was missing. The *BWHR* was calculated for each hour, *h,* of the day using the following periods:

period 1 = 5/02/99	through 5/15/99
period 2 = 5/16/99	through 5/29/99
period 3 = 5/30/99	through 6/12/99
period 4 = 6/13/99	through 6/26/99
period 5 = 6/27/99	through 7/10/99
period 6 = 7/11/99	through 7/24/99
period 7 = 7/25/99	through 8/07/99
period 8 = 8/08/99	through 8/14/99 (not a two week period)

This gave us a unique $BWHR_{hp}$ for each hour of the day for each of the eight bi-weekly periods. The appropriate $BWHR_{hp}$ was then applied to calculate an estimated count for each period, EC_p, according to the following formula:

$$EC_p = \sum_{d=1}^{n_p} \left(\sum_{h=0}^{23} \left(\frac{mt_{dhp}}{60} \times BWHR_{hp} \right) \right)$$

, where
p = one of eight unique bi-weekly periods
n = number of days in the period *p*
h = hour of the day in military convention
d = day of the period
EC_p = estimated count for one of the eight periods
mt = missing time for each hour of each day in the period (if no time is missing, $mt = 0$)
BWHR = bi-weekly hourly rate

Total escapement was then calculated as follows,

$$TC = FC + \sum_{p=1}^{8} \left(EC_p \right)$$

Where,

TC	=	total weir count,
FC	=	fish counted,
P	=	one of the above eight periods
EC_p	=	estimated count for
mt	=	missing time
$BWHR$	=	*bi-weekly hourly average fish per hour for each hour of the day*
d	=	day of observation
h	=	hour of the day
x	=	one of eight periods for calculating BWHR

Table 6. Estimates of lake escapement of adult sockeye salmon from 1988 to 1999 modified from Jacobs *et al.* (1996), corrected old data (1988 through 1995), and new data (1996 to 1999).

Year	**No. Adults Observed (Old Data)**	**Estimated Run Size (Old Data)**	**No. Adults Observed (New and Corrected Data)**	**Estimated Run Size (New and Corrected Data)**
1988	218 (only 3 days of collection)	2,191	218	3,599[1]
1989	143	588	143	603
1990	175	263	175	385
1991	N/A	684	377	684
1992	1,175	2,166	1,197	2,548
1993	69	≤267	69?	?
1994	N/A	498	213	585
1995	N/A	314	N/A	314
1996	429	1,702	429	1,778
1997	258	1,133	258	1,133
1998	980	1,406	980	1,406

1999	1,945	2,076	1,945	2,076

1. This expansion is based on too little data for accurate quantification.

Operation of the adult weir in 1998 included several modifications and improvements from past years. Adult sockeye enumeration at the weir occurred earlier in 1998 than in most years in the past and was maintained for a longer period. In addition, a time-lapse video system was tested at the weir to determine if video technology could be used to improve the accuracy of run size estimates.

The sockeye weir was deployed on May 5, 1998, in the upper Ozette River just downstream of the Olympic National Park Service (ONPS) foot bridge located at the lake outlet. Observers monitored the weir for a total of 56 nights from May 5, 1998, through July 2, 1998. No visual or camera data was collected on May 30, 1998, due to scheduling problems. The video system was operated for 53 days and nights from June 15, 1998, to August 6, 1998, when the weir was removed. Adult sockeye counts had dropped to one fish in a seven-day period prior to weir removal.

Using a combination of visual and camera techniques (Figure 6), the total unadjusted 1998 adult sockeye run size was 939 fish (Figure 7). As can be seen by examining the daily adult sockeye weir counts (Figure 8), the first sockeye observed passing through the weir were on May 7, 1998. The last sockeye observed passing through the weir was on August 4, 1998. Peak counts occurred between June 10 and June 20, 1998, with a peak count of 47 adults observed on June 14, 1998.

Daily sockeye counts were comprised of visual only counts, camera only counts, and an overlap between the two. Since higher numbers of adults were observed passing through the weir by the camera than by human observers, a detailed comparison of the efficacy of both methods was conducted (Figure 9). These data were compared over a 10-day period from June 22 to July 1, 1998. During this period, the camera recorded 202/939 (22%) of the total number of sockeye observed passing through the weir. Of the 202 fish recorded by the camera, 23 sockeye (11%) passed through the weir during daylight hours outside of the observer viewing period. Visual counts comprised 114/202 (56%) of the total sockeye observed by the camera. The camera counted 63/202 (32%) of passing fish that were missed by the observer. The video recording system counted 202/114 (177.2%) more fish than did the visual observer during the test period in 1998 (camera to visual observer count ratio was 1.772). Since the early portion of the run size estimate was comprised of visual observer only data, which was 44% lower than the camera data during the test period, we adjusted the early portion of this weir data to generate an adjusted run size estimate (Figure 7; foot note 6 above).

Operation of the adult weir in 1999 again included several modifications and improvements from past years. The sockeye weir was deployed on April 30, 1999, in the same location as in 1998. The underwater video camera was installed on May 1, 1999, and was positioned closer to the weir opening to improve the clarity of images of passing adult sockeye. The camera position was adjusted over several days following initial deployment to optimize image clarity and field of view. Observers monitored the weir for a total of 99 nights from 2200 to 0700 beginning April 30, 1999, and ending August 6, 1999. The video system was operated for 153 days and nights from May 1, 1999, to September 30, 1999, when the weir was removed. Camera footage recorded approximately two adult sockeye per day from August 1 through August 15, 1999. Since all of the tapes from late-August and September have not yet been fully reviewed, the exact run size for 1999 has not been determined; however, it is expected that less than 100 fish will be observed when these final tapes are reviewed.

The first adult sockeye were observed on May 2, 1999, and peak counts, ranging from 16 to 84 adults, were observed from May 16 to June 14, 1999 (Figure 10). Daily observations of visual observers were compared to those of the camera over a 98-day period, with more than 1,400 paired observations recorded and analyzed (Figures 11 and 12). Approximately 3,500 visual and camera data points are being merged and compared. As can be seen, camera counts were almost always higher than visual counts. Visual counts comprised approximately 1,168/1,945

(60%) of the total sockeye observed by the camera. The camera counted 777/1,945 (40%) of passing fish that were not enumerated by visual methods. Of the 777 fish missed by visual observers, 518 (67%) of these passed outside of the visual monitoring period (Figure 13) and the other 259 fish (33%) not visually counted were attributable to human error as described below. The video recording system counted 1,945/1,168 (166.5%) more fish in 1998 than did the visual observer during the test period (camera to visual observer count ratio of 1.665).

Human error, which caused approximately 259 adult sockeye to not be enumerated in 1999 by visual observers, was influenced by the inability of the observers to see the fish, weather conditions, observers inability to accurately count fish when large schools rapidly passed the viewing area, observers not being present while on duty, equipment failures, and distractions (primarily seal, otter, and raccoon activity). The hourly percentage of adult sockeye passing the weir on their migration upstream into Lake Ozette was measured from May 1 to August 14, 1999 (Figure 14). It was determined that daytime passage through the weir was directly related to the water surface elevation of the lake (Figure 4). A linear regression revealed a highly significant ($p<0.001$) relationship between surface elevation and percentage of daytime passage (0700 to 2200; Figure 5).

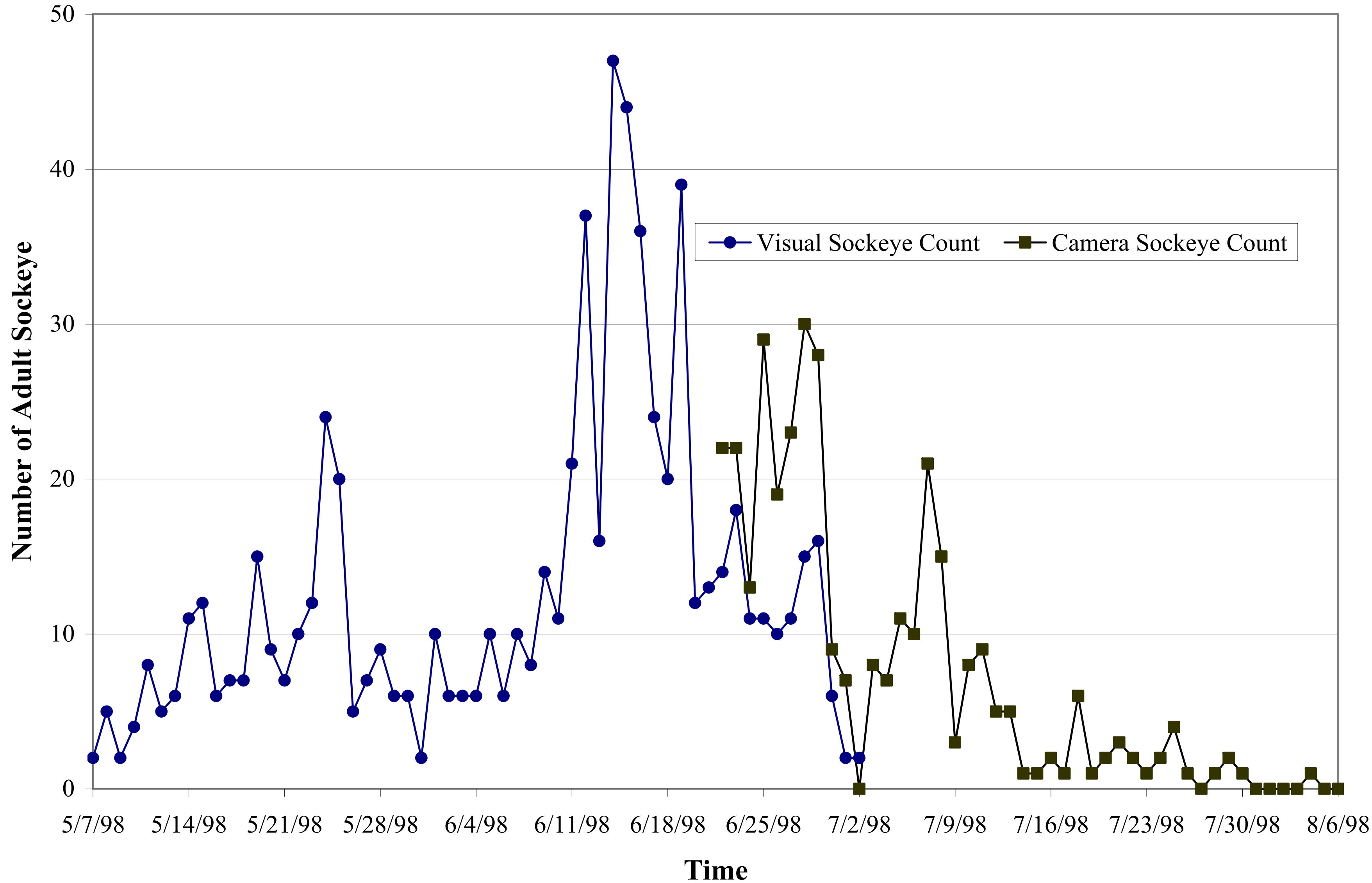

Figure 6. 1998 visual and camera daily weir counts of adult sockeye entering Lake Ozette.

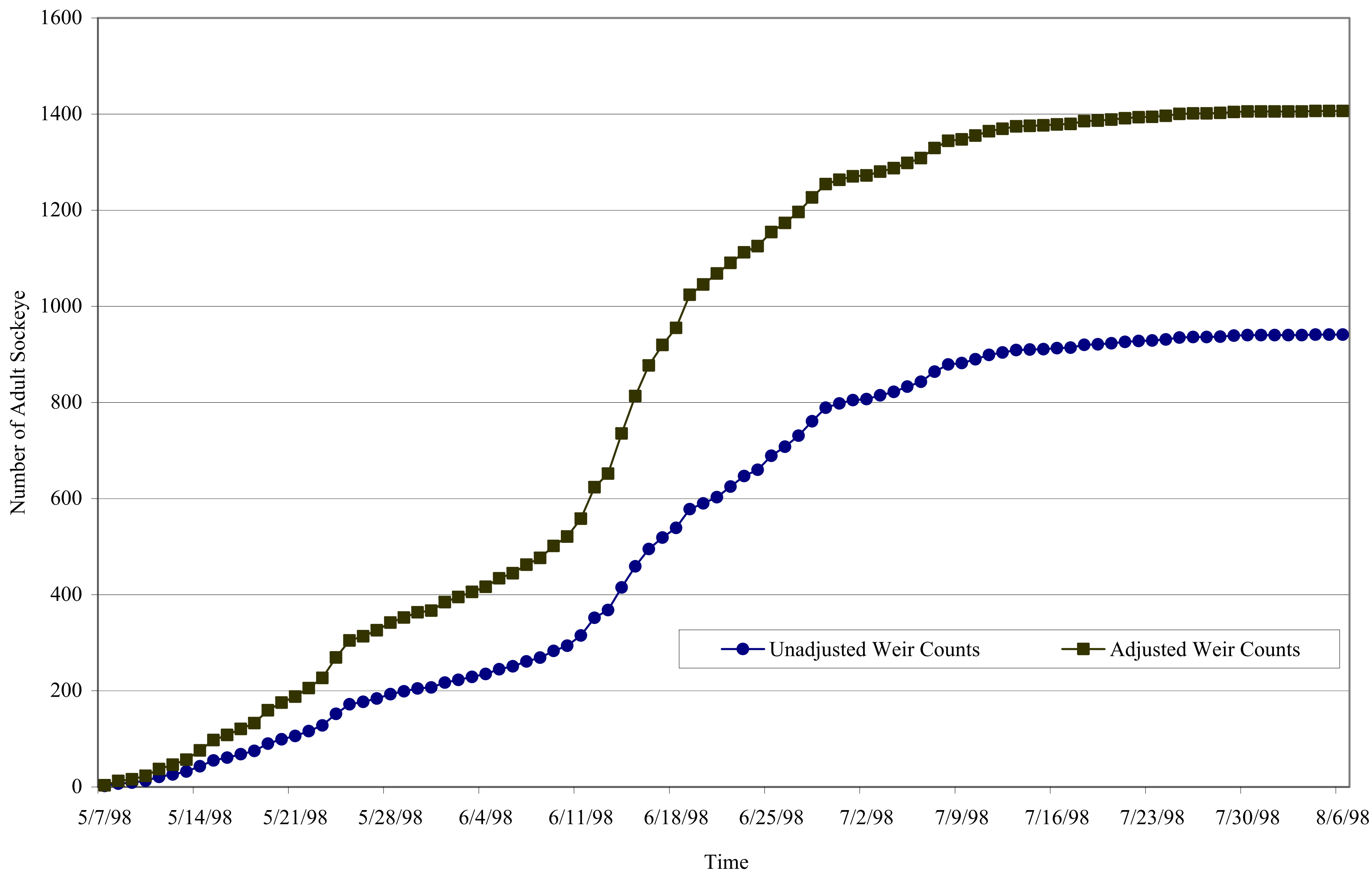

Figure 7. 1998 cumulative run size adjusted and unadjusted weir counts of adult sockeye.

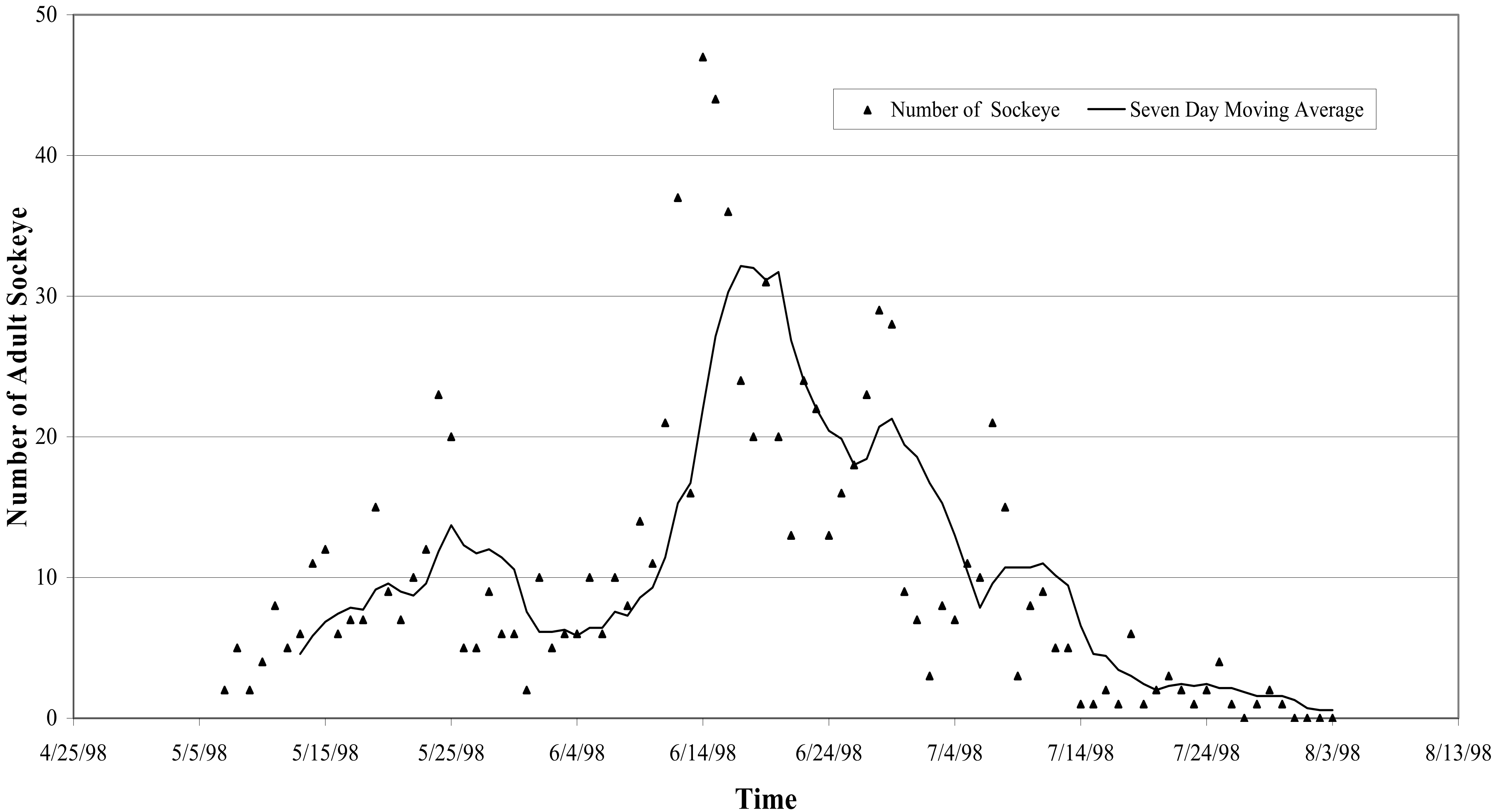

Figure 8. 1998 unadjusted daily sockeye counts.

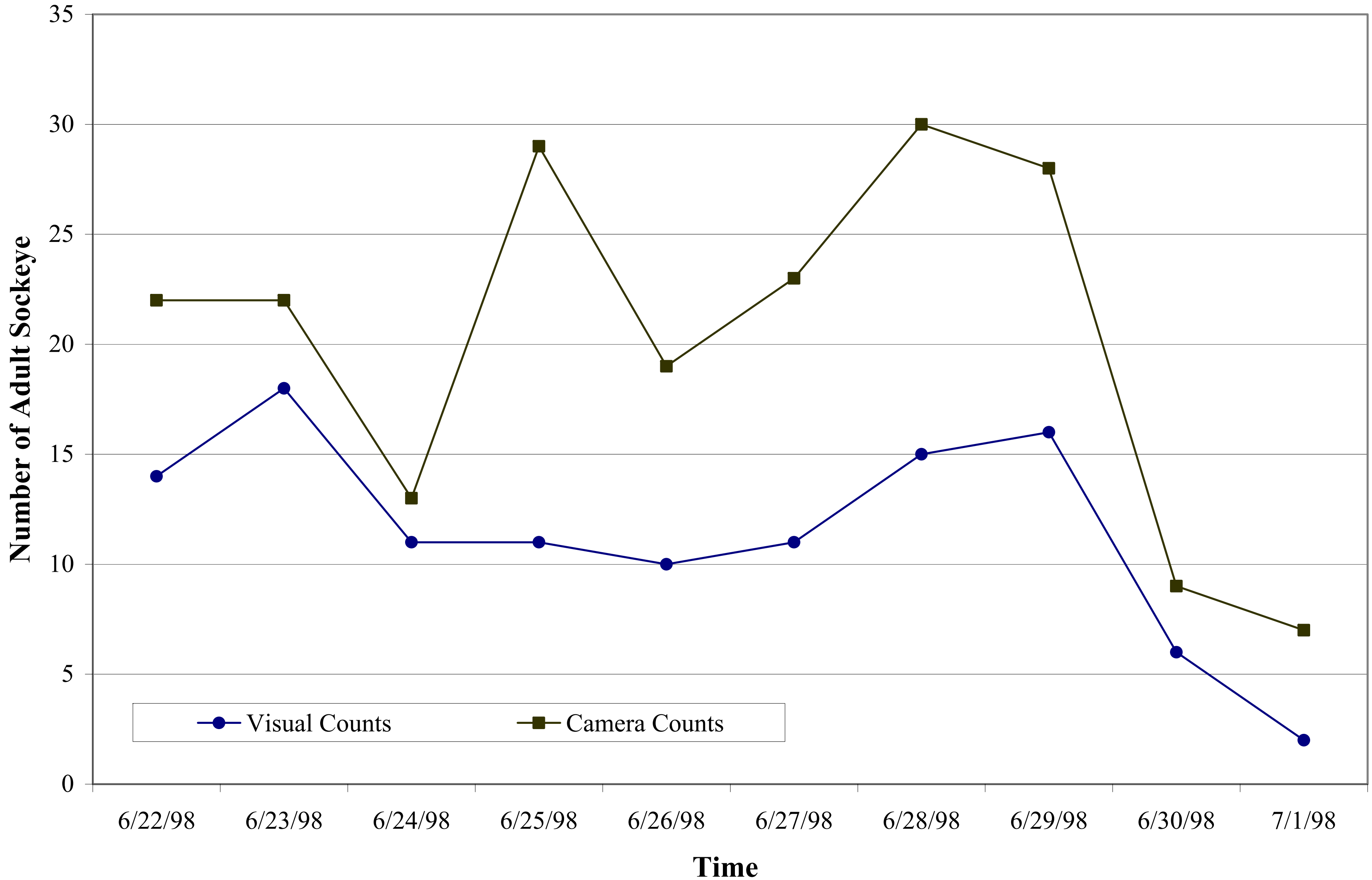

Figure 9. 1998 comparison of visual and camera adult sockeye daily weir counts over a ten day period.

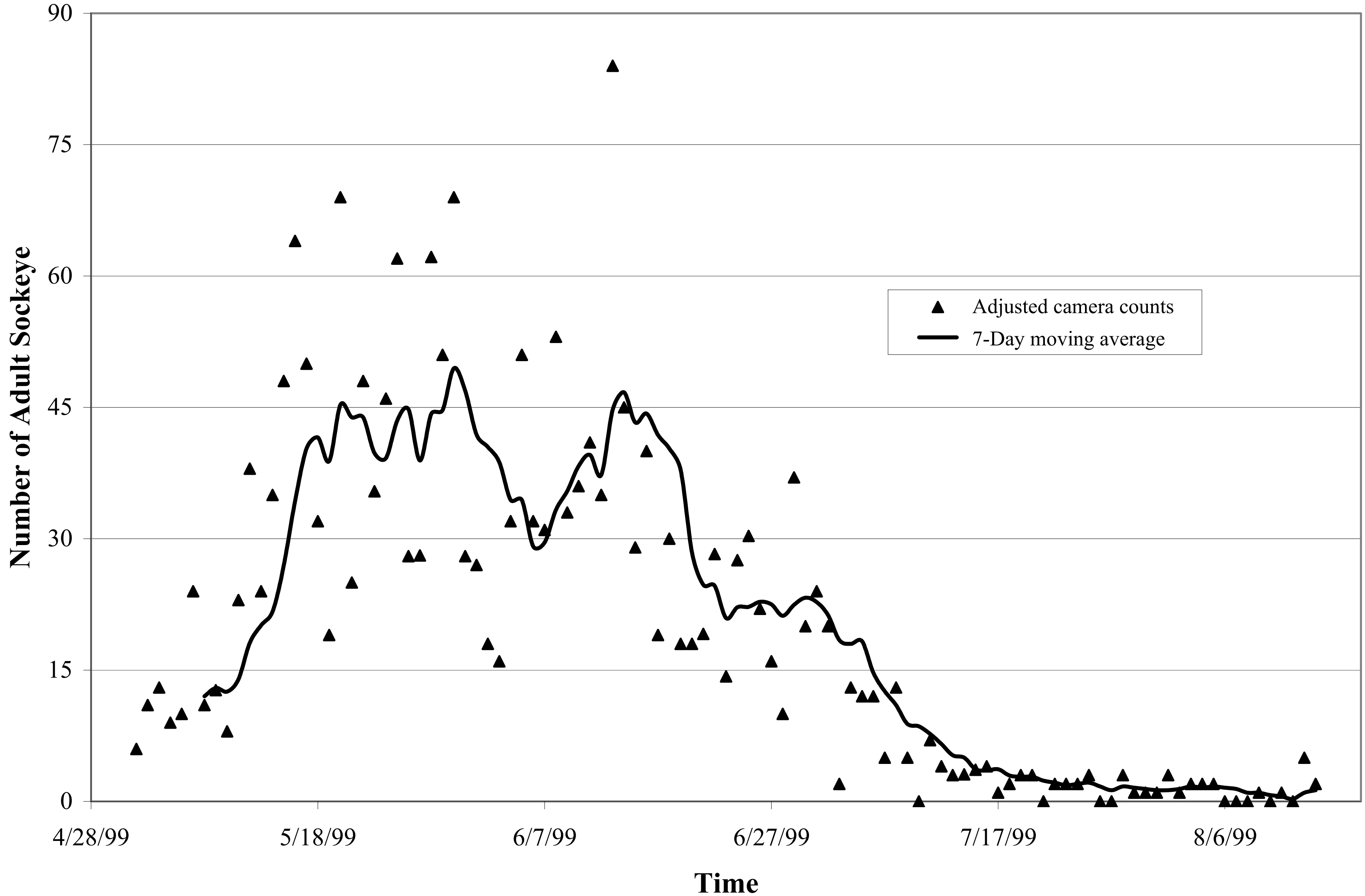

Figure 10. 1999 adjusted daily camera sockeye counts.

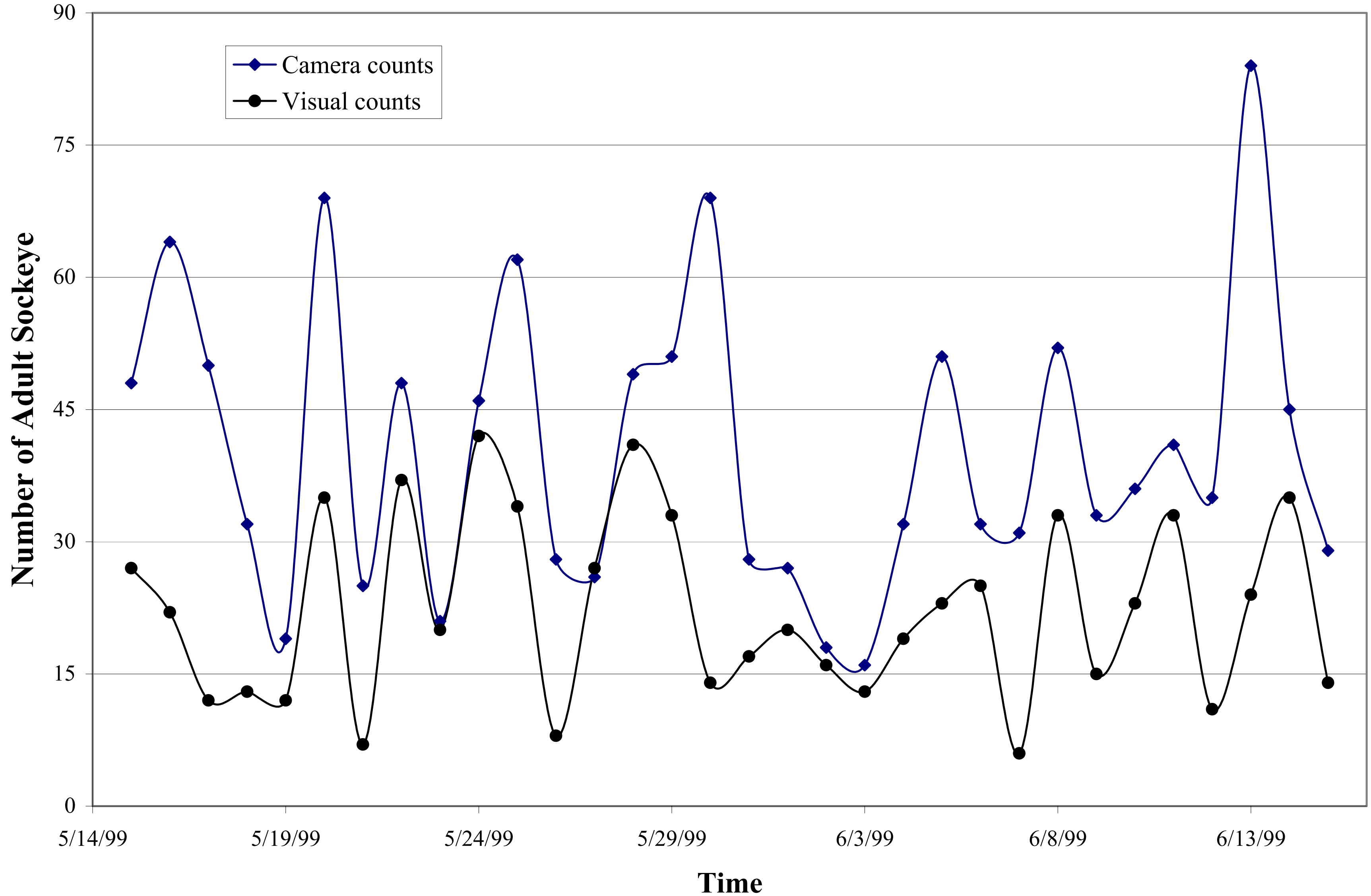

Figure 11. Comparison of 1999 daily visual and camera adult sockeye counts.

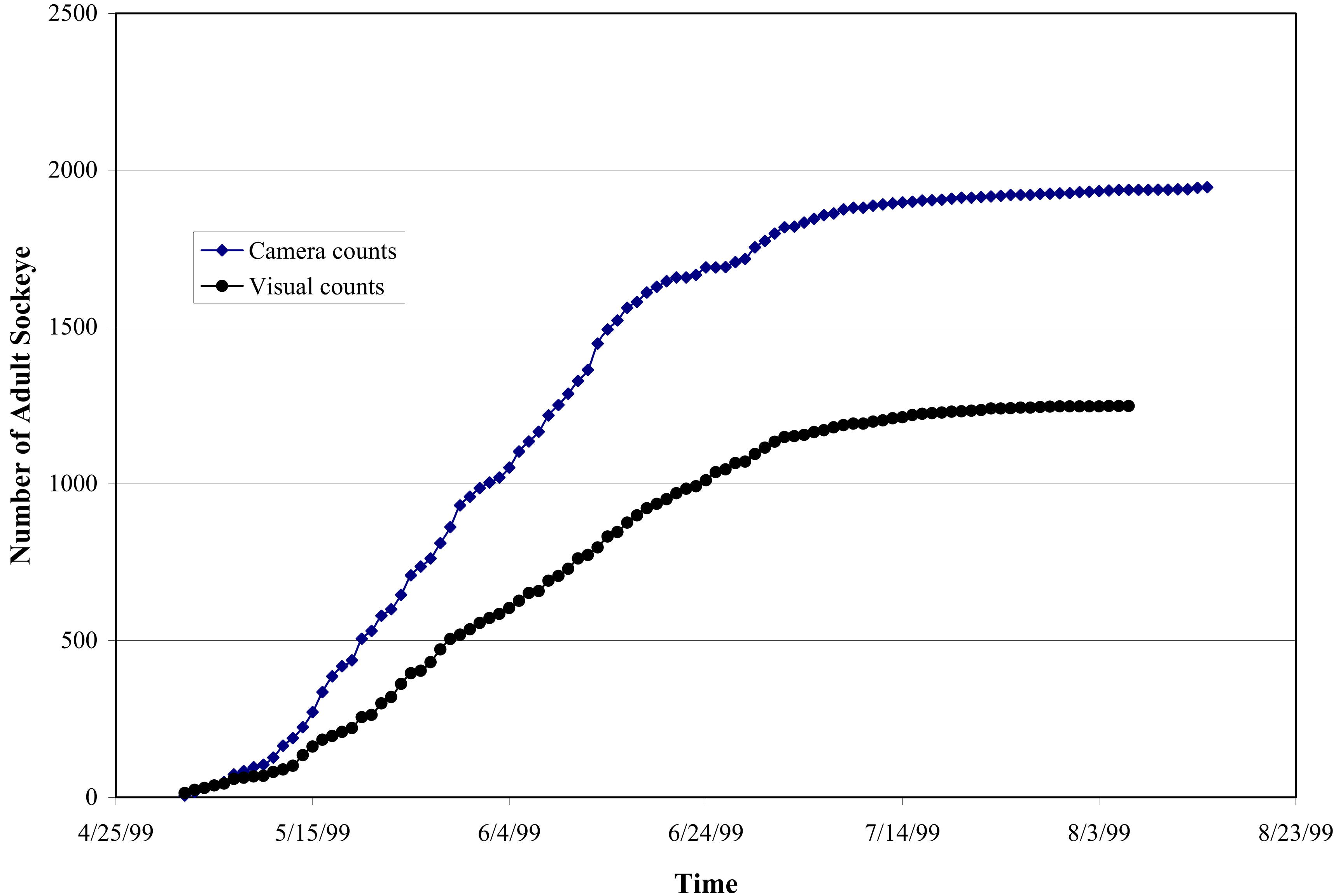

Figure 12. 1999 unadjusted cumulative camera and visual adult sockeye counts.

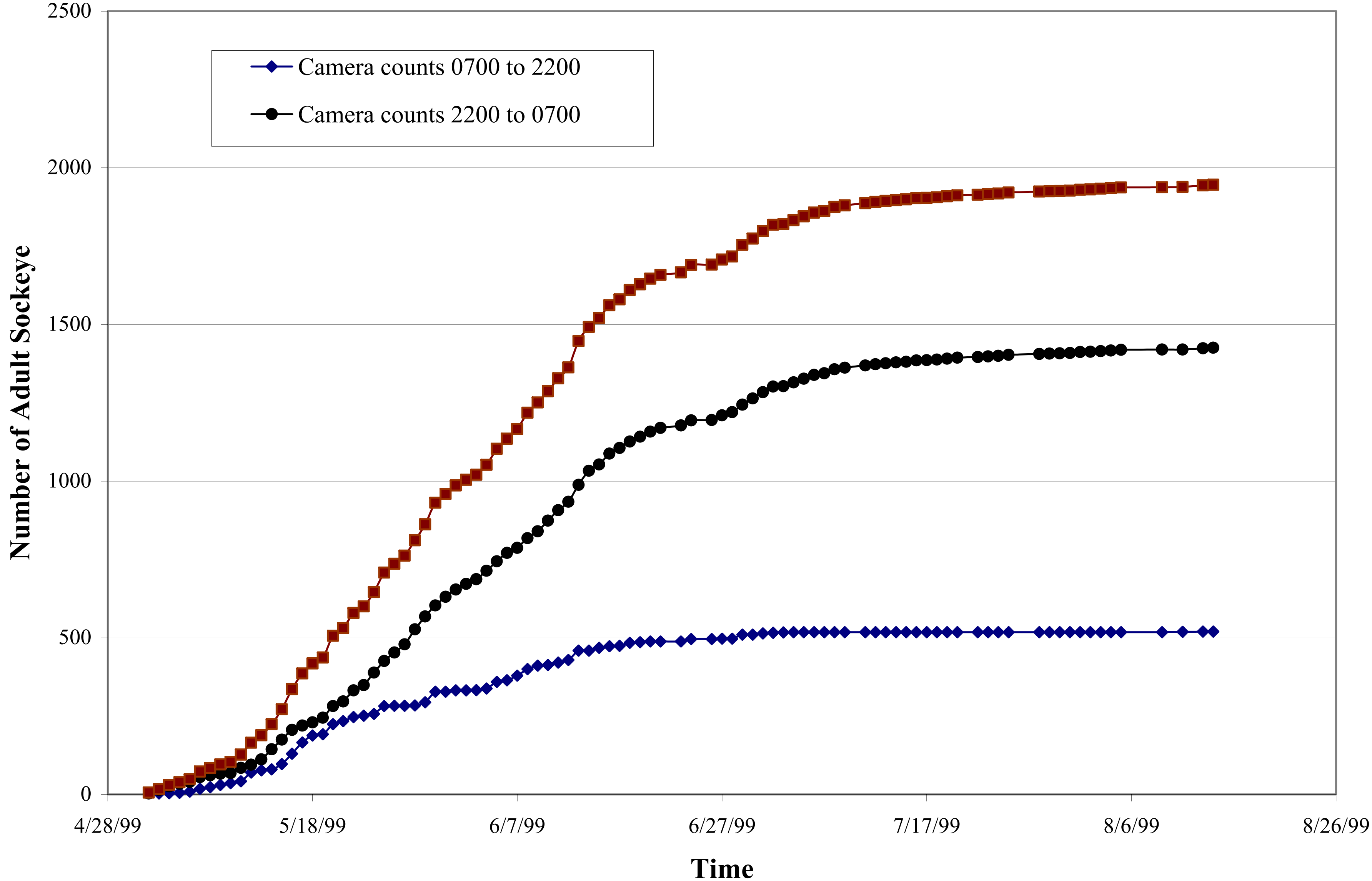

Figure 13. 1999 day, night, and combined day and night unadjusted cumulative adult sockeye counts.

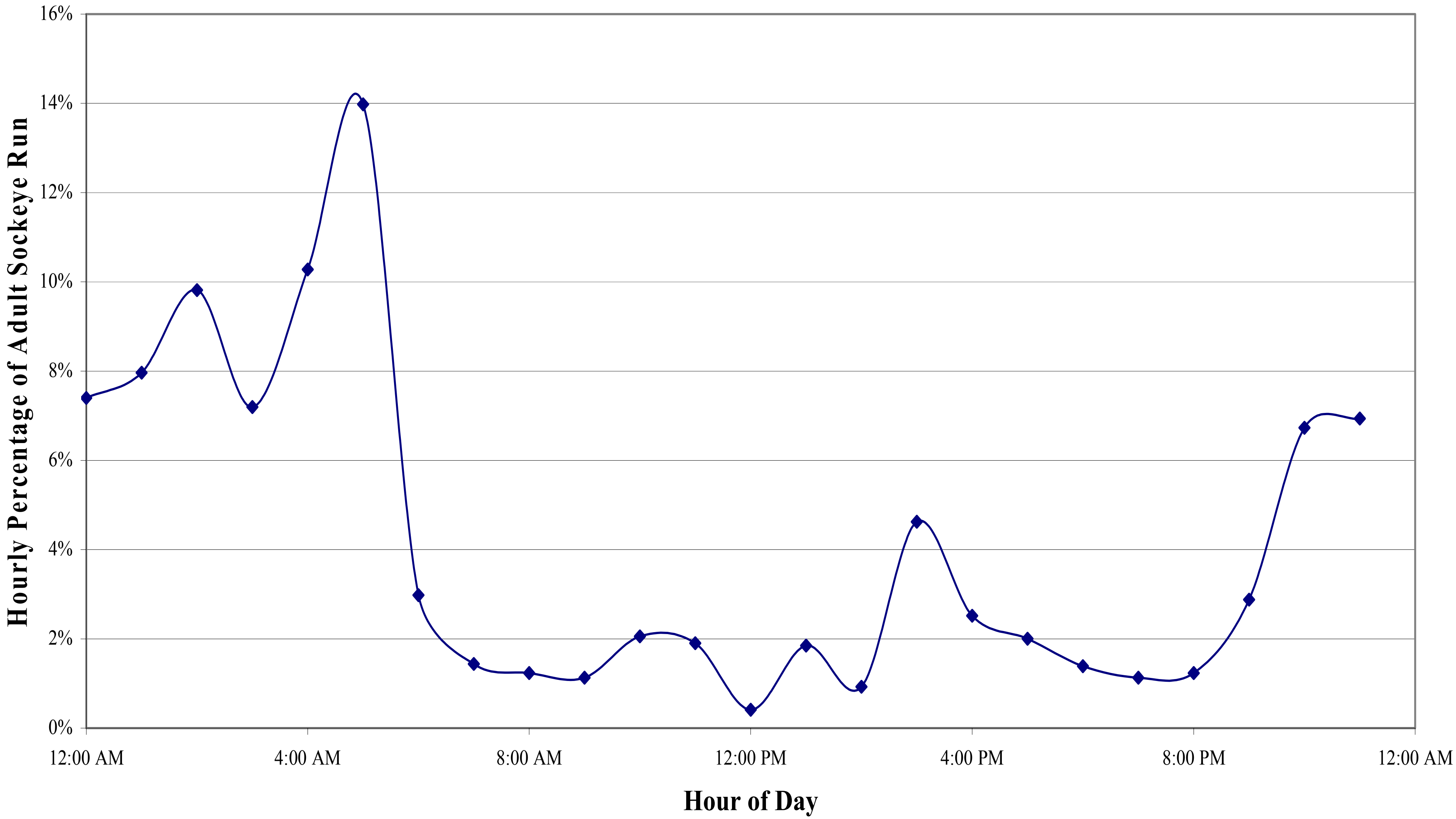

Figure 14. Hourly percentage of adult sockeye migration into Lake Ozette from May 1 to August 14, 1999.

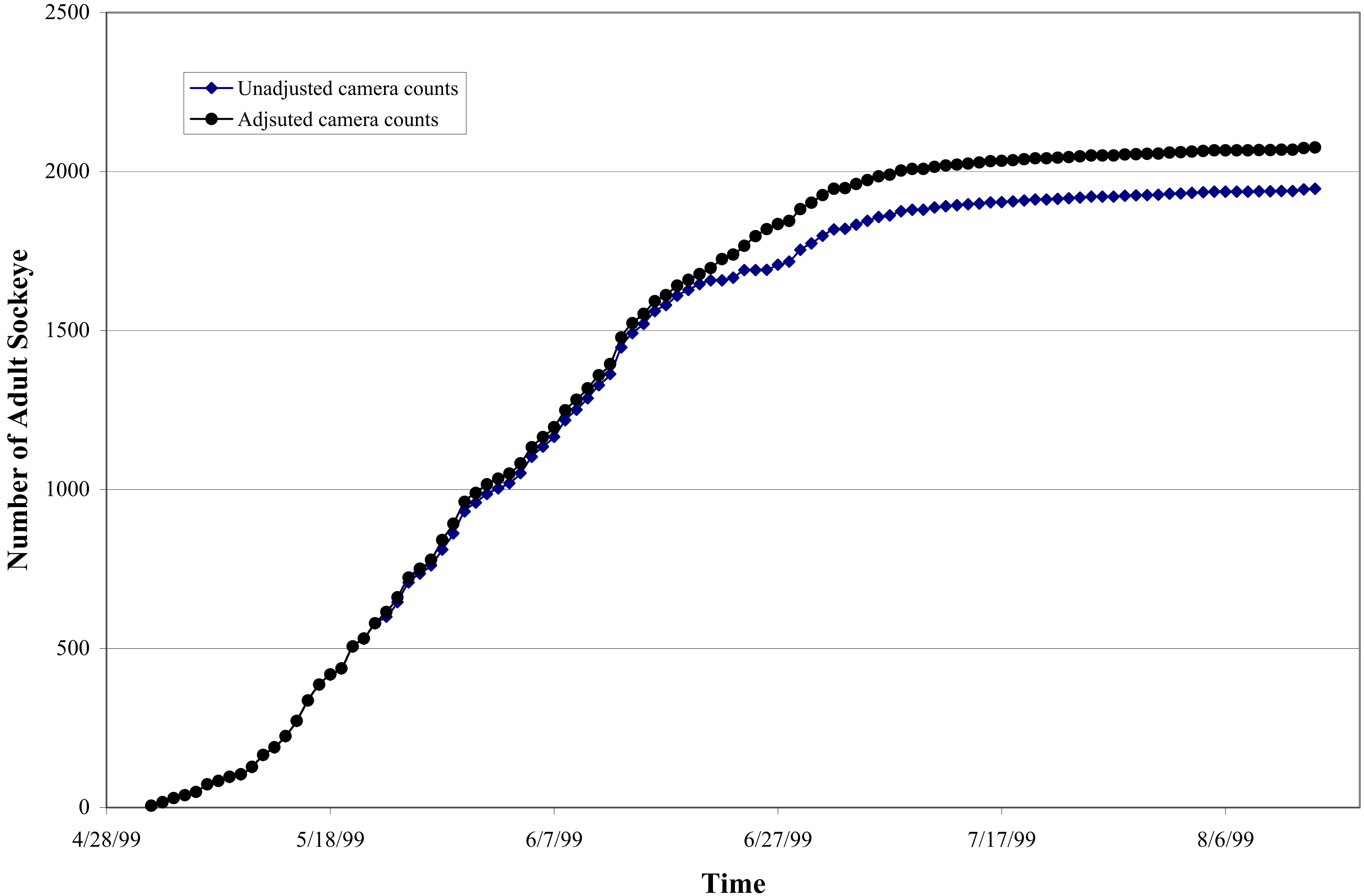

Figure 15. 1999 cumulative adjusted and unadjusted camera sockeye counts.

2.2.3) Progeny-to-parent ratios, survival data by life-stage, or other measures of productivity for as many brood years as available:

Sockeye releases into Umbrella Creek have resulted in a tributary spawning aggregation comprised of natural origin recruits (NOR's) and F1 hatchery returns (Table 7).

Table 7. Peak adult sockeye counts from Umbrella Creek (RM 4.78 to 2.52).

RELEASE YEAR	HATCHERY RELEASES	RETURN YEAR	NO. ADULTS	DISTANCE (MI)	PEAK FISH/MILE	PEAK NOR/MILE
1992	48,186[1]	1995	44	2.26	19	na
1993	No Release	1996	79	2.26	35	35
1994	39,040[2]	1997	135	2.26	60	na
1995	44,411[2]	1998	96	2.26	42[4]	na
1996	45,220[3]	1999	312	2.26	138	52

[1] 48,186 fingerlings were the combined lake and creek releases of which 7,645 were released into Umbrella Creek.
[2] Lake release only.
[3] All fish were released into Umbrella Creek.
[4] Surveys didn't include the peak spawn timing due to excessive turbidity.

In 1999, the incidence of adipose clips was determined from 30 carcasses and 26 captured spawn outs recovered from Umbrella Creek (56 total). The tentative estimated sockeye spawning escapement for 1999/00 in Umbrella Creek was 400. It was calculated that approximately 14% of the spawners in Umbrella Creek were sampled (56/400). Of the 56 samples, 6 were clearly adipose fin clipped, 45 were clearly not clipped, and five potentially had partial clips (base of adipose fin was visible, however, saprolegnia covered the tops of the fins making definitive recognition not possible). Based upon an adipose fin clipping rate of 25% in release year 1996 (brood year 1995), it was calculated that a minimum of 47.1% (24/51) of the fish were of hatchery origin. If all questionable fish were adipose fin clipped, a maximum of 78.6% (44/56) were of hatchery origin. The midpoint of this range was 62.9%. Since there were 400 spawners in Umbrella Creek in 1999, the 62.9% estimate would yield 251 hatchery origin spawners. With 45,220 fry released directly into Umbrella Creek in 1996 (progeny of brood year 1995), this would correspond to a survival rate, from one gram hatchery fry to spawning adult, of approximately 0.6%.

Based on the above estimates of hatchery returns, the percentage of NOR's in Umbrella Creek in 1999 ranged from 21.4% to 52.9%. The peak NOR/mile shown for 1999/00 (Table 7) was calculated as the midpoint of the range (37.2%). This was then used to calculate a peak NOR/mile of 52. This roughly yields a spawner replacement ratio of 2.7 (52/19). The tentative estimated sockeye escapement for 1999/00 in Umbrella Creek was 400, of which approximately 149 were of natural origin (400 x 0.372). The estimated 101 and 149 adult NOR's in 1996 and 1999, respectively, and the 1995/1999 spawner replacement ratio of 2.7 indicate a definitively increasing trend in reproductive success. This spawner replacement ratio is impressively high for a spawning aggregation undergoing the selective pressures of adaptation to a totally new environment.

Significant evidence of natural reproduction occurred in 1996 when Umbrella Creek adult returns of 35 fish per mile surveyed were observed four years after the 1992 brood year, when no hatchery sockeye were released. Because no hatchery progeny were released in 1992, and returns are predominantly four years old, these 1996 adults provide additional data on the growing NOR spawning aggregation in Umbrella Creek.

Recovery of eyed eggs from a one-time redd-pumping procedure in Umbrella Creek was accomplished in February 1999, to confirm the first recorded monitoring of reproductive success of NOR's. Subsequent recovery of nearly 5,000 subsequent outmigrating swim up NOR fry was accomplished by Makah Fisheries Management using fyke nets (Figure 16) from mid-April to late-May, 1999, before any hatchery fish were released into Umbrella Creek. Actual NOR fry abundance was postulated to be considerably higher because the outmigration was already underway when trapping was initiated on April 14, 1999, and because trapping was interrupted on numerous occasions beginning in early May due to flooding, when a majority of the fry were expected to be emigrating. In addition, trap efficiency was very poor, averaging approximately 50% using much larger one gram fry, which were presumed to be easier to trap than smaller swim up fry. Despite these inefficiencies, peak daily counts exceeded 700 swim up sockeye fry by the third week of April 1999 (Figure 17).

Hatchery fry per spawner ratios can be calculated from the data shown previously in Table 3. Approximately 750 progeny have been released on average per spawner. Although data is lacking, past survival rates of hatchery fish were at least 0.6% and recent survival rates of fry and fingerlings may be closer to 1%; which would yield replacement rates ranging from approximately 4.5 to 7.5 for hatchery fish (MFM unpublished data).

2.2.4) Annual proportions of hatchery and natural fish on natural spawning grounds for as many years as possible:

The annual proportions of natural and hatchery origin adults returning to natural spawning grounds in Umbrella Creek were discussed in the previous Section 2.2.3. In 1995, 10,570 left-ventral-clipped fed fry of a total release of 44,411 fed fry (23.8% of the release were fin-clipped) were released from brood year 1994 immediately offshore of the major spawning beaches in Lake Ozette. The beach spawner surveys conducted in 1998 found only 2/165 beach spawners sampled from the beaches that were left ventral clipped (1.21%). Both clipped fish were found on Olsen's Beach near the release site and none were found on Allen's Beach. An expansion for unmarked fish suggests that approximately five percent of Olsen's Beach spawners in 1998 were of first generation hatchery origin from this nearby lake fry plant. The majority of the returning hatchery origin adults in 1998 returned to Umbrella Creek where early imprinting on the hatchery water source influenced their return. Releases off of the beaches and ventral fin clipping have been discontinued.

In 1996, 11,248/45,220 (24.9%) of the release into Umbrella Creek from brood year 1995 were adipose clipped yet out of a total of 121 adults captured in 1999 on the spawning beaches, none (0%) were adipose clipped. This demonstrates that straying is very low or nonexistent when fish are reared and released into the tributary as fry or fingerlings.

Of a total of 1,915 adults that were hard-counted by the video camera at the weir in 1999, which resulted in a preliminary expanded estimate of total run size of 2,076 in 1999, 138 were reviewed by a second tape reviewer (7.2% of the images or 6.6% of the total run size). We estimate that 85% of the 2,076 fish had images on camera that were clear enough to be visibly reviewed for adipose clips. Of the 1,915 images, 138 were examined for clips and 3.3% were found to be clipped. When expanded for the 75% that were unmarked, the estimate is that 13.2% of the run was of hatchery origin. Since the expanded run size was approximately 2,076 in 1999, the total number of F1 hatchery returns was estimated to be 274, which closely simulates the number of clipped hatchery fish (251) that were estimated from surveys in Umbrella Creek as described in the previous Section 2.2.3. If the camera and survey numbers were accurate in 1998, they would yield an overall adult holding mortality rate in the lake of 8.4% for hatchery origin sockeye.

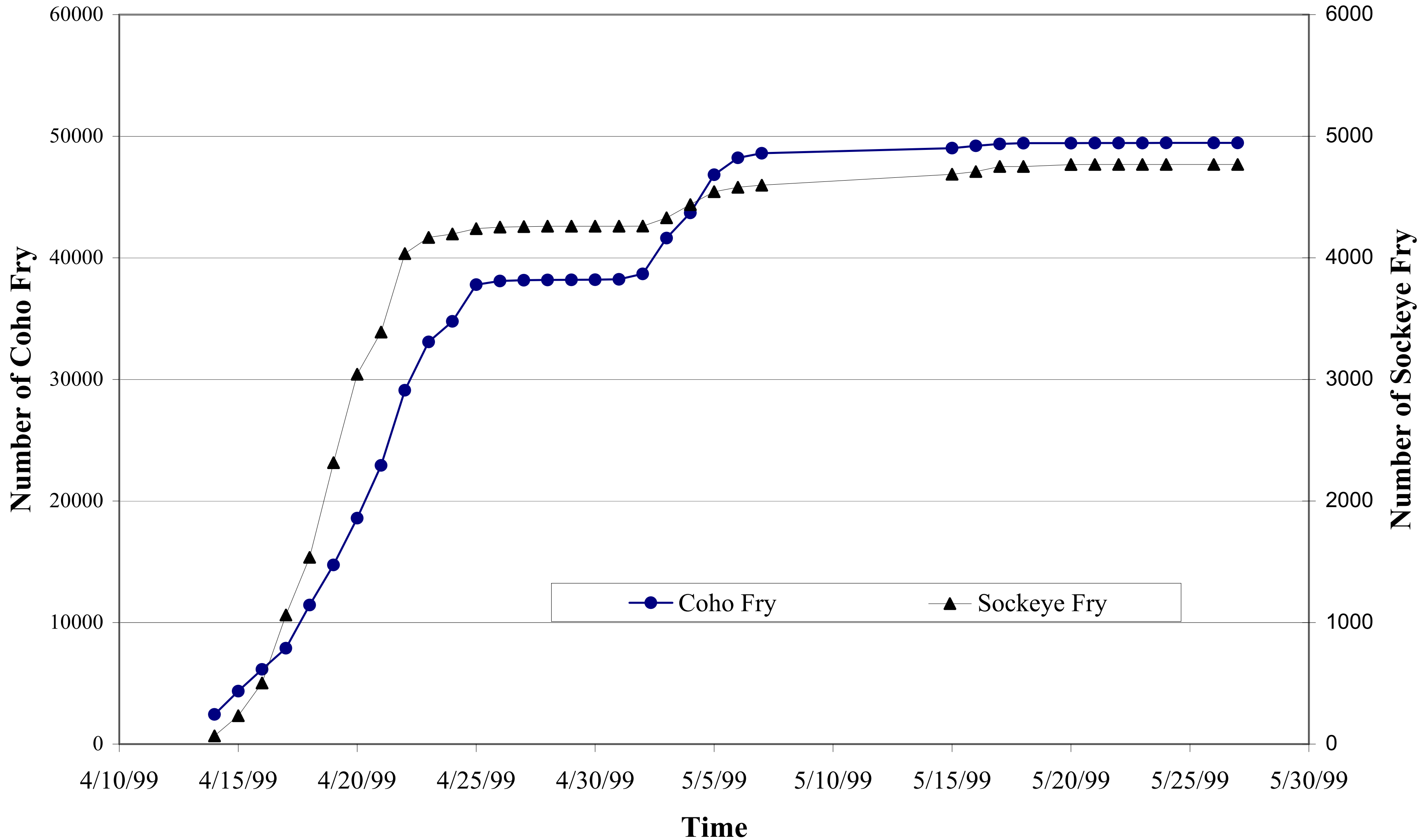

Figure 16. Spring 1999 Umbrella Creek fyke net cumulative coho and sockeye fry outmigration counts.

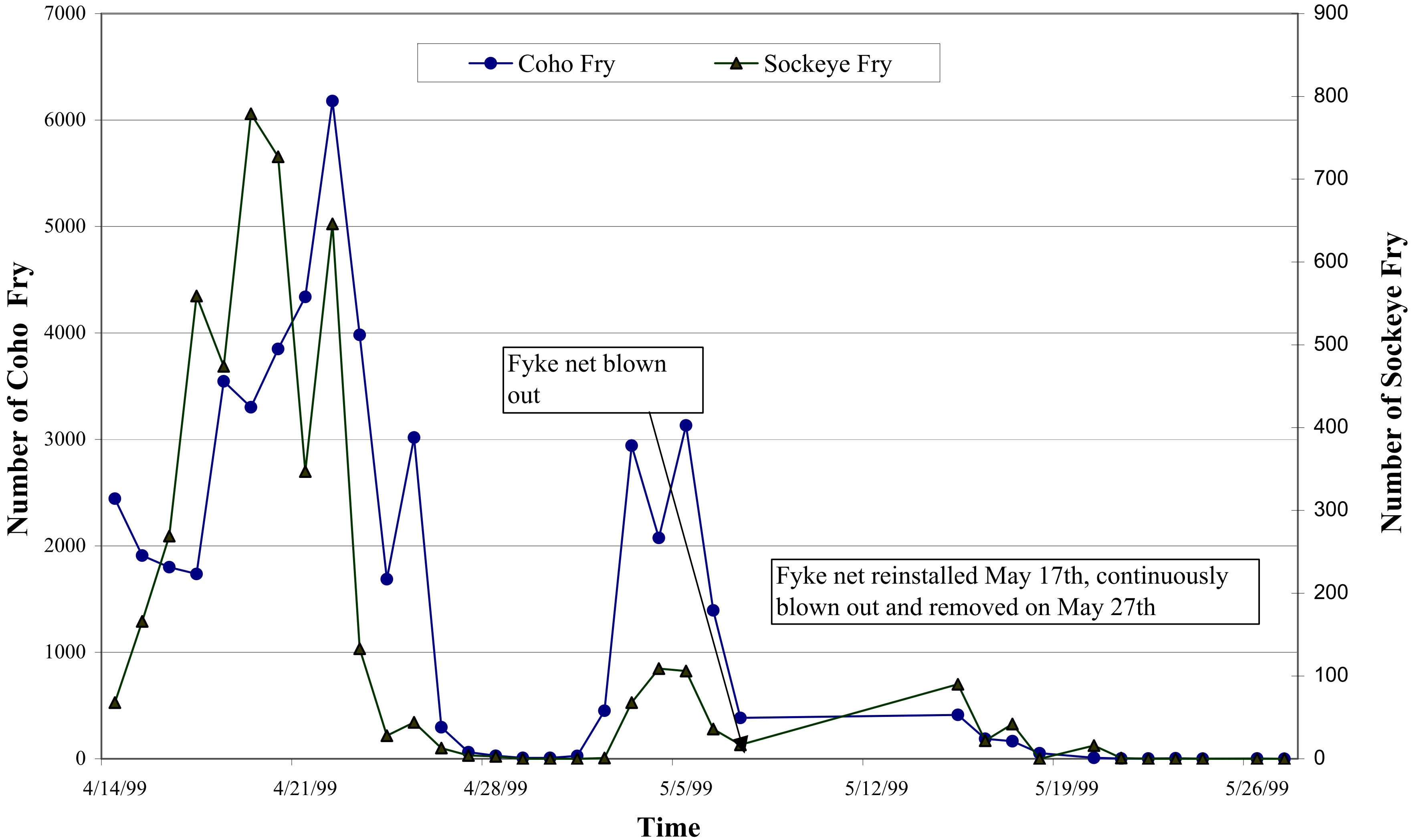

Figure 17. Spring 1999 sockeye and coho daily fry outmigration counts in Umbrella Creek.

2.2.5) Status of natural population relative to critical and viable population thresholds (See Instruction A):

Lake Ozette sockeye were listed as threatened on March 25, 1999. Recent findings indicate that earlier methods used to estimate abundance grossly underestimated the true run size. As previously described in detail in Section 2.2.5, run size data prior to 1996 is either unavailable or inaccurate. The abundance trend for the overall population and for individual aggregations can only be calculated in upcoming years based on recent, more accurate run size estimates since 1996. Since estimates through 1997 were not based on camera counts, we only have the more recent and accurate camera data from 1998 and 1999 to base trend analyses on in the future; with portions of these estimates also derived from visual observations that were combined with portions derived from camera data.

Based on recent adult counts monitored by a new underwater video camera, the average run size appears to have exceeded 2,200 adults over the past four years (1997-2000) with low year classes well above 1,000 adult returns. The actual 1999 return of approximately 2,076 adults was more than seven times higher than the expected return, based on run size estimates cited in Jacobs *et al.* (1996) and the 10% rate of decline purported in the Federal Register (FR 63 11750). An even larger return than that observed in 1999 is projected for 2000 (projected to be approximately 4,500 adults) These relatively large returns, and other recent findings regarding the errors in past abundance estimates, provide new data upon which it will be possible in upcoming years to determine the status of this population relative to critical and viable population thresholds. Historic abundance, productivity, spatial distribution, and genetic and life history diversity of the population as a whole, as well as for individual spawning aggregations on lake beaches or in tributaries, is not understood.

2.3) Relationship to harvest objectives:

Due to the early timing of the entry of Ozette sockeye run entering the Ozette River in late-April and peaking by late-May to mid-June annually well in advance of Canadian and U.S. sockeye fisheries, there are currently no known harvest impacts on Lake Ozette sockeye salmon. There has been no harvest of Lake Ozette sockeye for the past four generations (16 years). In the 10 years prior to that, minimal cultural and ceremonial harvests by the Makah Tribe ranged from 0 to 84 fish with mean ± SEM of 25 ± 9. In the 10 years prior to that, harvests remained minimal averaging less than 500 fish. Purported harvests of Lake Ozette sockeye greater than 4,000 fish were only reported from 1949 to 1951 and are suspect as previously described in Section 2.2. Historic abundance estimates should not be based on these undocumented fish catches. Regardless, harvest has not been a factor for more than 36 years.

The long range future harvest goal is to conduct sustainable Tribal C&S and commercial fisheries in conjunction with sustainable non-Tribal commercial and/or sport fisheries. A harvest management plan will be developed before any commercial fisheries are implemented in the future in conjunction with a reassessment of this HGMP. Future commercial fisheries will proceed cautiously and will occur only after escapement goals are determined for spawning aggregations and when sufficient numbers of harvestable surplus fish are present. Proper fisheries management will be accomplished by intensive monitoring to ensure that minimum escapement goals are achieved for each spawning aggregation.

2.4) Relationship to habitat protection and recovery strategies:

Describe the major factors inhibiting natural production (if known), such as habitat protection efforts with expected natural production benefits over the short-term and long-term

Background:

In the last century, nearly the entire Lake Ozette watershed has been converted from old growth coastal temperate rainforest to timber production in 35 - to 50 - year rotations. Historically, riparian areas within the basin were dominated by old growth Sitka Spruce, Douglas Fir, Western Hemlock, and Western Red Cedar stands. Nearly all of these riparian stands have been clear-cut and are currently in early stages of succession. Larger tributaries are now dominated by extensive stands of red alder. Extensive road building, clear-cut timber harvest, and agricultural development have severely degraded freshwater productivity within the Basin. Jacobs *et al*. (1996), Blum (1988), and Dlugokenski *et al*. (1981) have speculated that spawning habitat degradation, as a result of timber harvest, has been a primary factor for the decline of the Lake Ozette sockeye salmon population.

The cumulative effects of intensive land-use practices within the last century, and continuing presently, pose risks to sockeye salmon productivity within both the tributaries and the lake. High levels (17.1% average for Ozette tributaries) of fine sediment (<.85mm) within spawning gravels are believed to compromise egg to emergence survival of sockeye within Big River and Umbrella Creek (MFM unpublished data; McHenry *et al*. 1994). McHenry *et al*. (1994) and MFM (unpublished data) found that road densities within the Ozette Basin were approximately 2.2 km/km^2. Road systems within the Basin have high connectivity with streams lacking appropriate cross-drains, which may be a significant source for the high levels of fine sediment observed by MFM (unpublished data) and McHenry *et al*. (1994).

The lack of a fully functional riparian forest along tributaries to Lake Ozette is believed to contribute to channel destabilization, loss of pool quantity and quality, increased scour, and increased summer temperatures. The introduction and invasion of non- native plant species, such as Reed Canary Grass along several stretches of spawning beaches within Lake Ozette, coupled with increased levels of fine sediment delivered to beaches via tributaries, are considered "plausible" factors for decline by Adkinson and Burger In Jacobs *et al*. (1996). Native willow and sedge species, which predominate the lakeshore, may also trap sediment and, in turn, grow better with additional sediment input. Irregular changes in lake level over time, plausibly due to removal of large woody debris from the Ozette River which may have, may have subsequently increased the encroachment of plant species on spawning gravels by reducing wave action energy-induced cleaning of spawning substrate. Also, it is expected that natural cleaning of spawning substrate by active spawning adults would decrease with the decline of beach spawners.

Current habitat protections:

The majority of Lake Ozette and most of the Ozette River lie within the Olympic National Park. The Makah Tribe's Ozette Reservation bounds the Ozette River for a small distance near the mouth. The Ozette Reservation is set aside as a Tribal Wilderness. A small amount of lakeshore property is owned by private interests, and falls under the jurisdiction of the Olympic National Park. Private timber corporations own the majority of the Lake Ozette watershed. Washington State regulates these lands. The primary regulatory authorities are the State's Department of Natural Resources (DNR), Department of Fish & Wildlife (WDFW), and the Department of Ecology (DOE). The WDFW administers the Hydraulic Code of Washington State, and DNR administers the Forest Practice Rules. To the extent that these statutes are enforced in the Ozette Watershed, they may provide some habitat protections. Recent Emergency Salmonid Rules and the new Forests & Fish Agreement may provide additional protections if the negotiated habitat buffers are large enough, and if enforcement, implementation, and adaptive management are all practiced with diligence, especially relating to the construction, maintenance, and abandonment of roads.

The Makah Tribe recently completed an analysis of the current forestry status within the Ozette Basin. From March 1997 to October 1998, there were 47 forest practice applications to clear cut 1,635 acres along 11 miles of fish-bearing streams, while constructing 16.5 miles of new roads within the Basin. As a result of this recently accelerated timber harvest, combined with the history of local timber companies' lack of compliance with State water quality standards and forest practice rules, the Makah Tribe has initiated an intensive forest practices compliance monitoring program with the DNR. Intensive monitoring has detected numerous forest practice and water quality violations ranging from direct delivery of large volumes (several tons) of fine sediment onto sockeye redds (skidder trails actually draining onto sockeye redds), to direct delivery of 50-250 tons of sediment into Type 1 waters, operating and yarding through and across Type 2 waters, logging within clearly identified fish-bearing forested wetlands, and additional riparian zone violations on several Type 1-3 streams. Efforts are underway to assure that these violations are recorded, and appropriate penalties are assessed. At the moment, there is a delicate balance between adversarial and cooperative relationships both amongst and between the resource co-managers and the timber industry.

Future habitat protection and restoration:

Our goal is to continue to develop a comprehensive habitat protection and restoration plan. This plan incorporates a watershed analysis/ecosystem approach that has a detailed limiting factors analysis. Treatments applied to habitat must address long- and short-term improvements and protections to freshwater sockeye productivity. Furthermore, this plan should address limiting factors affecting all salmonid species, because the Ozette watershed also has depressed runs of coho, chum, and possibly chinook salmon (if not already extinct), in addition to sockeye. Habitat restoration should have five main components: protection, prioritization, active restoration, passive restoration, and adaptive management. Habitat protection must incorporate a methodology similar to watershed analysis where inputs are ranked as high, moderate, or low hazards and areas of resource sensitivity have vulnerabilities ranked as high, moderate, or low; with a corresponding synthesis that determines how to protect public resources from being damaged in the future and which allows for resource recovery.

This habitat protection/restoration plan is critical to the Lake Ozette Sockeye Hatchery and Genetic Management Plan, Tribal Resource Management Plan, and Lake Ozette Sockeye Recovery plan because it will incorporate our current knowledge of limiting factors affecting Ozette sockeye with new information, through watershed assessment, of habitat quality, quantity, and distribution. This will allow for prioritization of reintroduction sites so that the ESU can maximize current habitat productivity to the fullest extent possible. Efforts are underway to develop a mechanism for statewide salmon recovery. The Makah Tribe has been providing input to this process through the North Olympic Peninsula Lead Entity Group and the Lake Ozette Sockeye Steering Committee, as well as directly with the state government. The Tribe is also conducting habitat and spawner surveys throughout the Lake Ozette watershed. A great deal remains to be learned about this ecosystem, the effects of land use activities on the population as a whole, and species interactions which may be limiting factors to recovery. Habitat protection and restoration are important elements of sockeye recovery, but they may not be the only limiting factors to healthy production of this ESU.

The habitat plan will continue to be critical to this plan because this HGMP will incorporate our current knowledge of limiting factors to focus reintroduction efforts to current existing areas which possess the most productive habitat where sockeye have the best opportunity to survive and build self-sustaining populations.

Identification of Limiting Factors for Lake Ozette Sockeye:

See Appendices A and B. A draft limiting factors paper is currently under revision (MFM *in preparation*).

Mapping and Characterization of Lake and Tributary Spawning Habitat:

An upper and a lower shoreline characterize the two currently identified primary sockeye spawning beaches in Lake Ozette, which differ in elevation by approximately two vertical meters.

In between the upper and lower beaches, the dominant vegetation consists of willow and sedge species. Reed Canary grass is established in a few areas on both beaches. Reed Canary grass has extensively colonized much of the Ozette shoreline, and is the dominant vegetation on much of the Big and Ozette Rivers. On both beaches, the majority of observed spawning activity occurs on the lower shoreline, which is one to five meters under water in the wet season. The sockeye appear to use substrate in both the tributaries and the lake of varying size, between smaller pea-sized aggregate to near cobble-sized aggregate, although peanut to golf ball-sized aggregate is the most common.

The Makah Tribe has conducted a beach mapping exercise, which, along with particle size measurements of substrates comprising the primary spawning sites on both beaches and spawner scuba surveys, should shed additional light on spawning habitat utilized by sockeye. Preliminary observations indicate that a majority of the spawning activity observed on Olsen's Beach in 1999 occurred on or near an upwelling seep. Upwelling springs may play an important role in redd site selection on lakeshore spawning areas.

Low gradient stream reaches characterize tributary spawning habitat in Umbrella Creek and Big River with moderate current and similar gravel sizes to lakeshore spawning areas. Sockeye in the lake and in the tributaries have been observed spawning in groups ranging from pairs spawning on redds less than one meter to aggregate groups exceeding 30 fish spawning in redd complexes covering an area more than 30 meters long and two to three meters wide.

2.5) Ecological interactions: (See Appendix C)

SECTION 3. WATER SOURCE

Provide a quantitative and narrative description of the water source (spring, well, surface, etc.), water quality profile, and any differences between hatchery water and water used by the naturally spawning population.

Dissolved oxygen is at saturation in our incubation facilities (10 to 11 ppm). Other water quality tests have not been conducted for the Umbrella Creek and Educket facilities as of 1999.

Water quality parameters were measured at MNFH on July 31 and August 1, 1985 (Advance Project Planning to Develop Additional Water Supplies; Makah National Fish Hatchery; USFWS, 1987). However, it was estimated that 65% of the water was returned back into the Sooes River above the intake line which then mixed with river water before being recirculated through the hatchery. Water reuse at MNFH has been discontinued except during an approximate two-week period toward the end of the summer annually during low flows when up to one third (1,000 gpm) of the hatchery effluent is diverted back into the Sooes River above the hatchery intake pump. No Ozette sockeye will be incubated during summer months. The following water quality parameters shown below should be viewed with the understanding that they occurred during water reuse.

The following mean water quality measurements occurred above MNFH inflow raceways: Dissolved Oxygen (8.63 mg/l), Alkalinity (37.33 mg/l as $CaCO_3$), Ammonia Nitrogen (0.027 mg/l), Nitrate Nitrogen (0.010 mg/l), Nitrite Nitrogen (0.002 mg/l), Total Suspended Solids (2.33 mg/l), Hardness (34.83 as CaCO3), pH (7.61), Turbidity (1.39 NTU), and Chloride (5.43 mg/l). The mean monthly water temperatures at MNFH were 7.3°C, 4.2°C, 5.8°C, and 6.8°C for November, December, January, and February, respectively, from 1982 to 1984. These are the four months that egg incubation is proposed in this HGMP to occur at MNFH.

The water temperature profiles were more recently measured by thermograph during the egg incubation period and compared between Umbrella Creek Hatchery and MNFH from November 23, 1998 to March 23, 1999 (Figure 18). As can be seen, the two facility temperature regimes closely mirrored each other. Water temperatures at MNFH (mean 6.4 ± 0.1°C; $n = 121$)

were slightly warmer than at the Umbrella Creek Hatchery (mean 5.7 ± 0.1°C; n = 121). The average daily difference (MNFH – Umbrella Creek Hatchery), compared between the two facilities, was only 0.8 ± 0.1°C; n = 121 (Figure 19).

A small tributary (WRIA tributary #20.0056) which enters Umbrella Creek at RM 4.5 supplies the hatchery water supply to the Umbrella Creek Hatchery. The water temperature at the Umbrella Creek facility was compared to the ambient river water temperature in Umbrella Creek at RM 4.0, which was adjacent to a major complex of spawning sockeye (Figure 20). This is the nearest spawning complex to the hatchery located approximately ½ mile downstream from the confluence of the tributary water supply to the facility. No sockeye have ever returned to the hatchery or its water supply. For the period where data is available from both sources, from December 1, 1998, to March 22, 1999, the temperatures were very similar between the hatchery tributary supply (mean 5.7 ± 0.1°C; n = 121) and Umbrella Creek (mean 5.7 ± 0.14 °C; n = 112).

Lake water temperatures and lake level were measured at both beaches. Three thermographs were placed (sub-gravel, immediately above gravel, and approximately one meter above gravel) adjacent to sockeye redds at Allen's Beach (Figure 21) and at Olsen's Beach (Figure 22). The thermograph placed above gravel on Olsen's Beach failed on 1/2/99 when water broke the seal. The thermograph placed one meter above gravel in the water column at Allen's Beach was lost when a drifting log ripped out the stake attaching the thermograph.

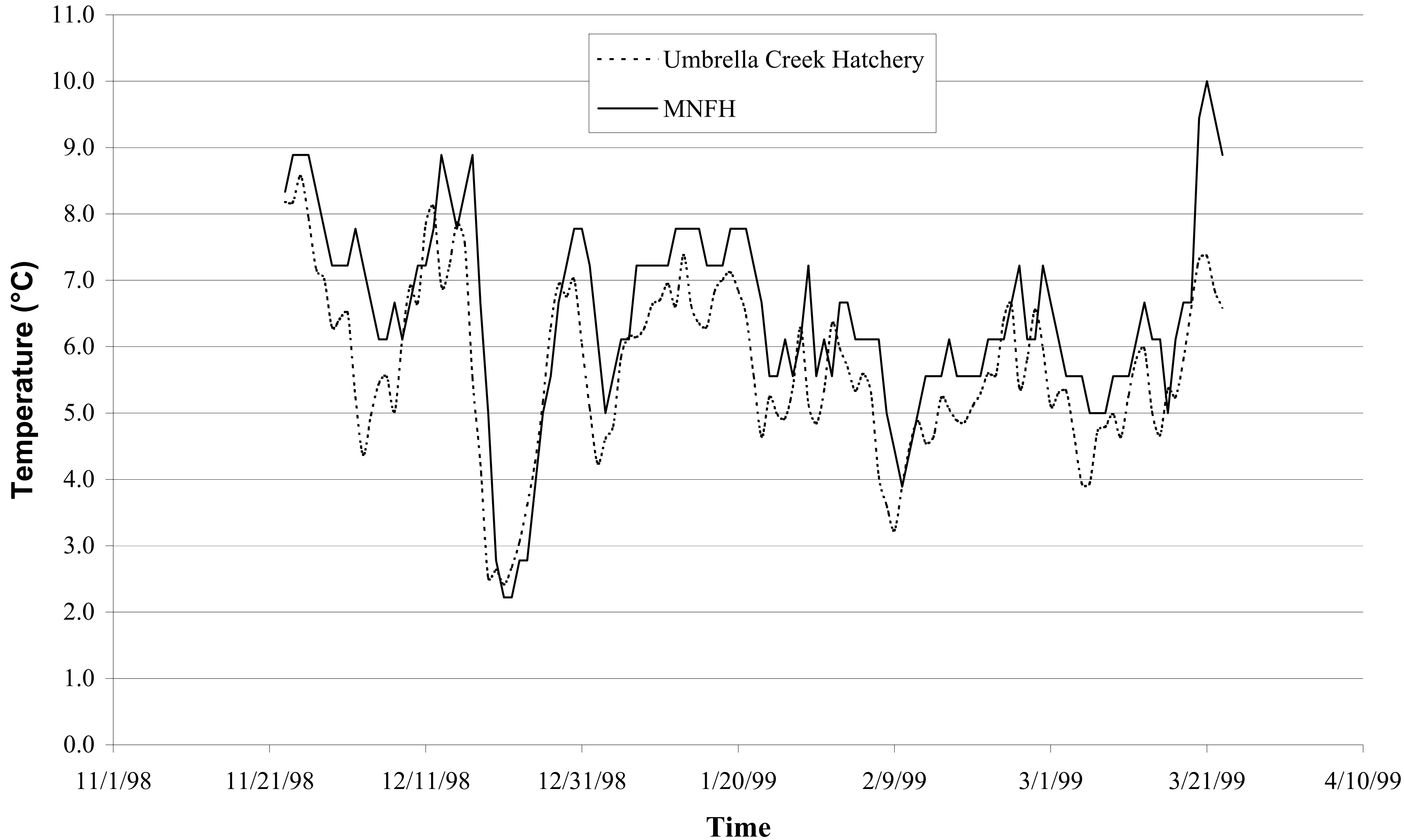

Figure 18. Temperature comparison between Makah National Fish Hatchery and Umbrella Creek Hatchery.

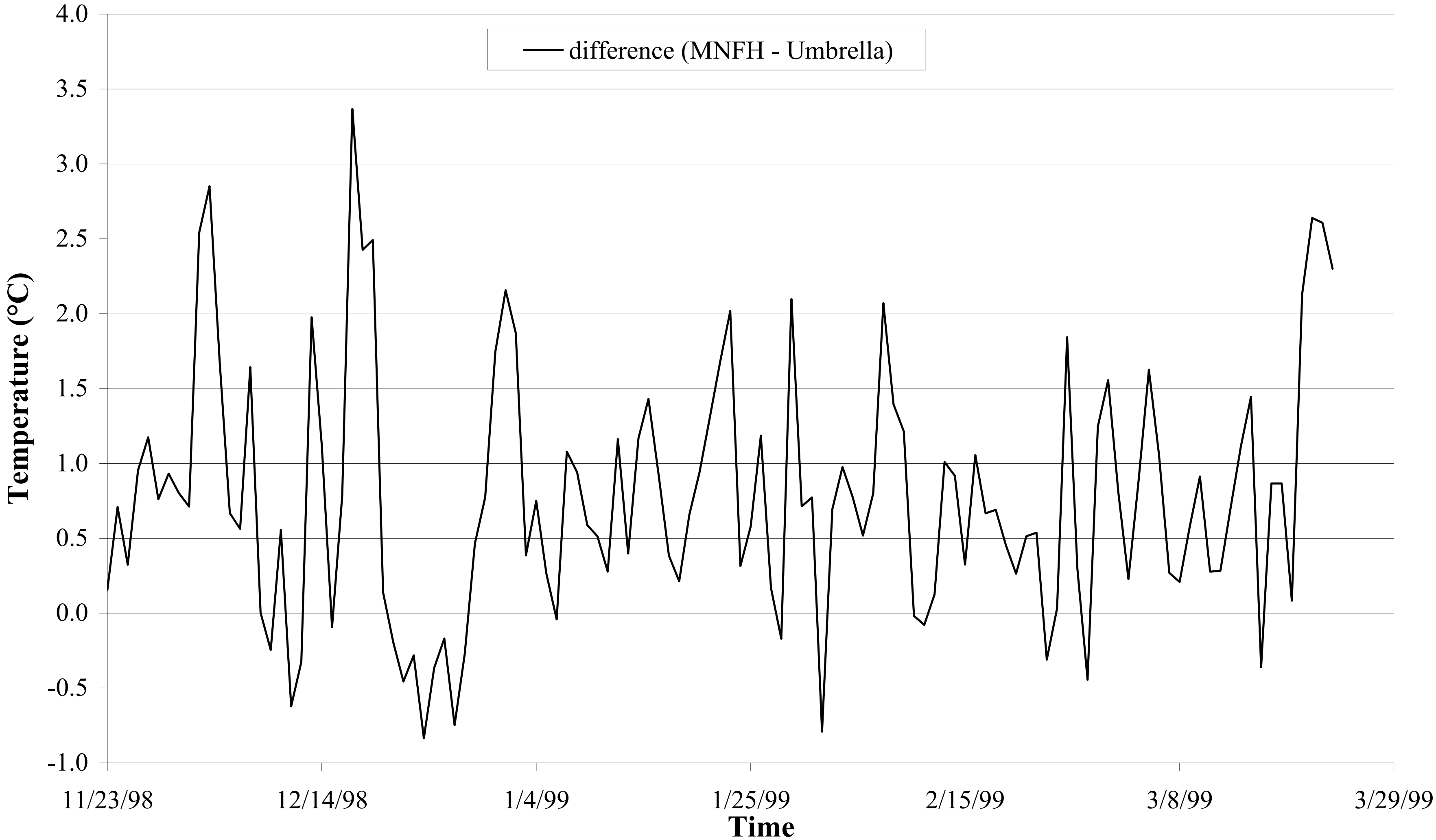

Figure 19. Daily Water Temperature Differences (MNFH - Umbrella Creek Hatchery; Degrees Celcius).

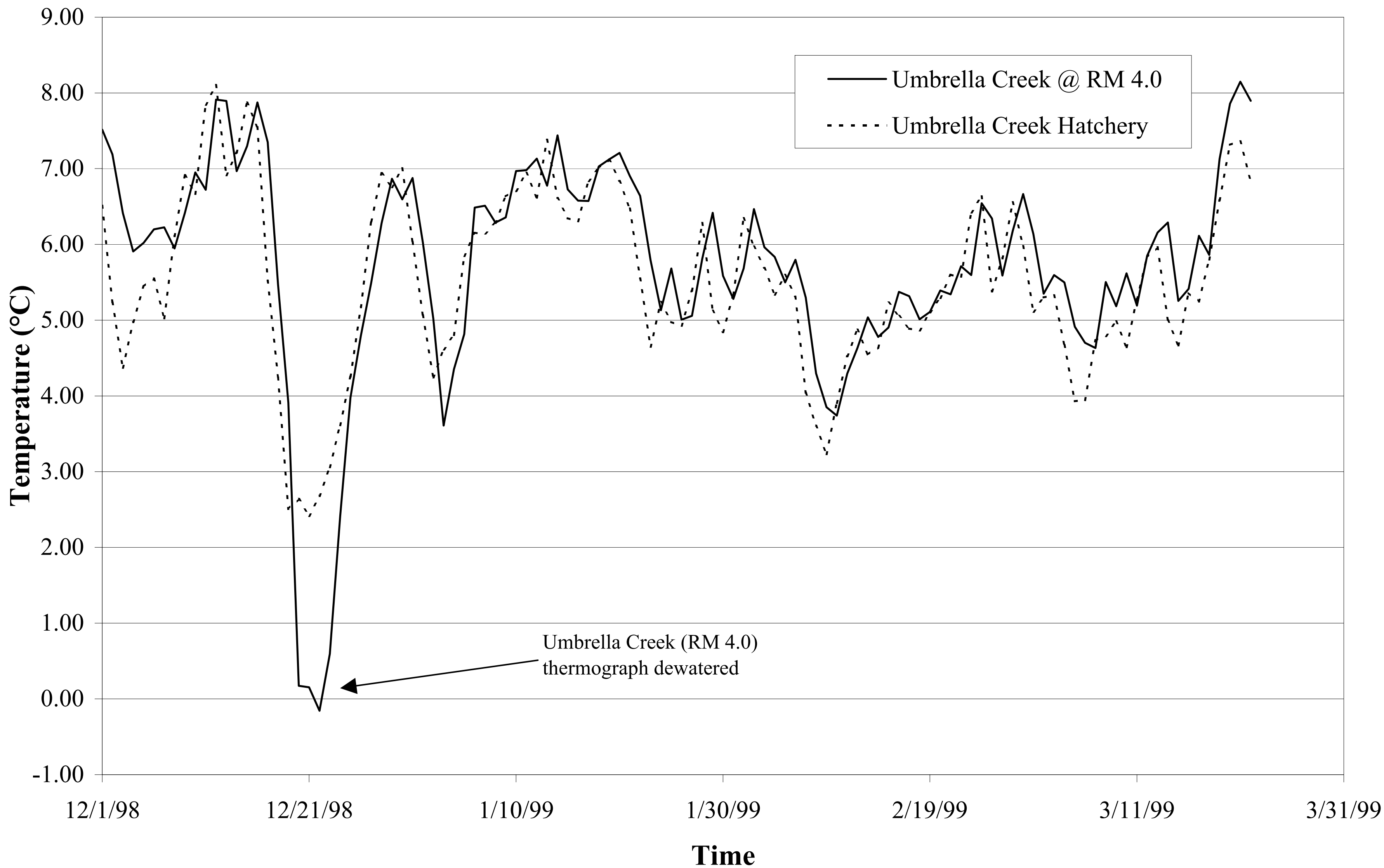

Figure 20. Winter 1998 to Spring 1999 comparison of Umbrella Creek Hatchery and Umbrella Creek (RM 4.0) water temperatures.

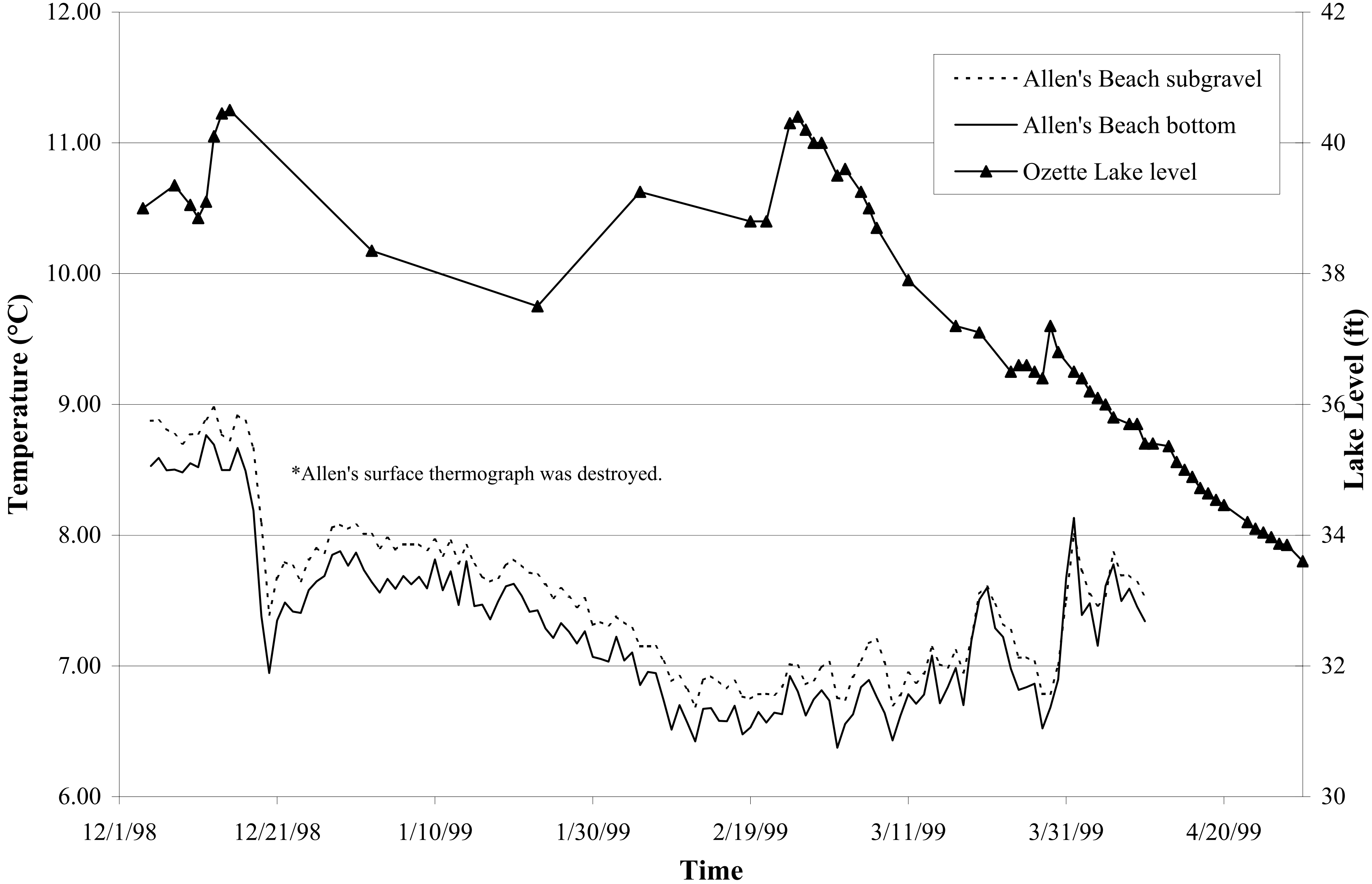

Figure 21. Winter 1998 to Spring 1999 Allen's Beach water temperatures and Ozette Lake level.

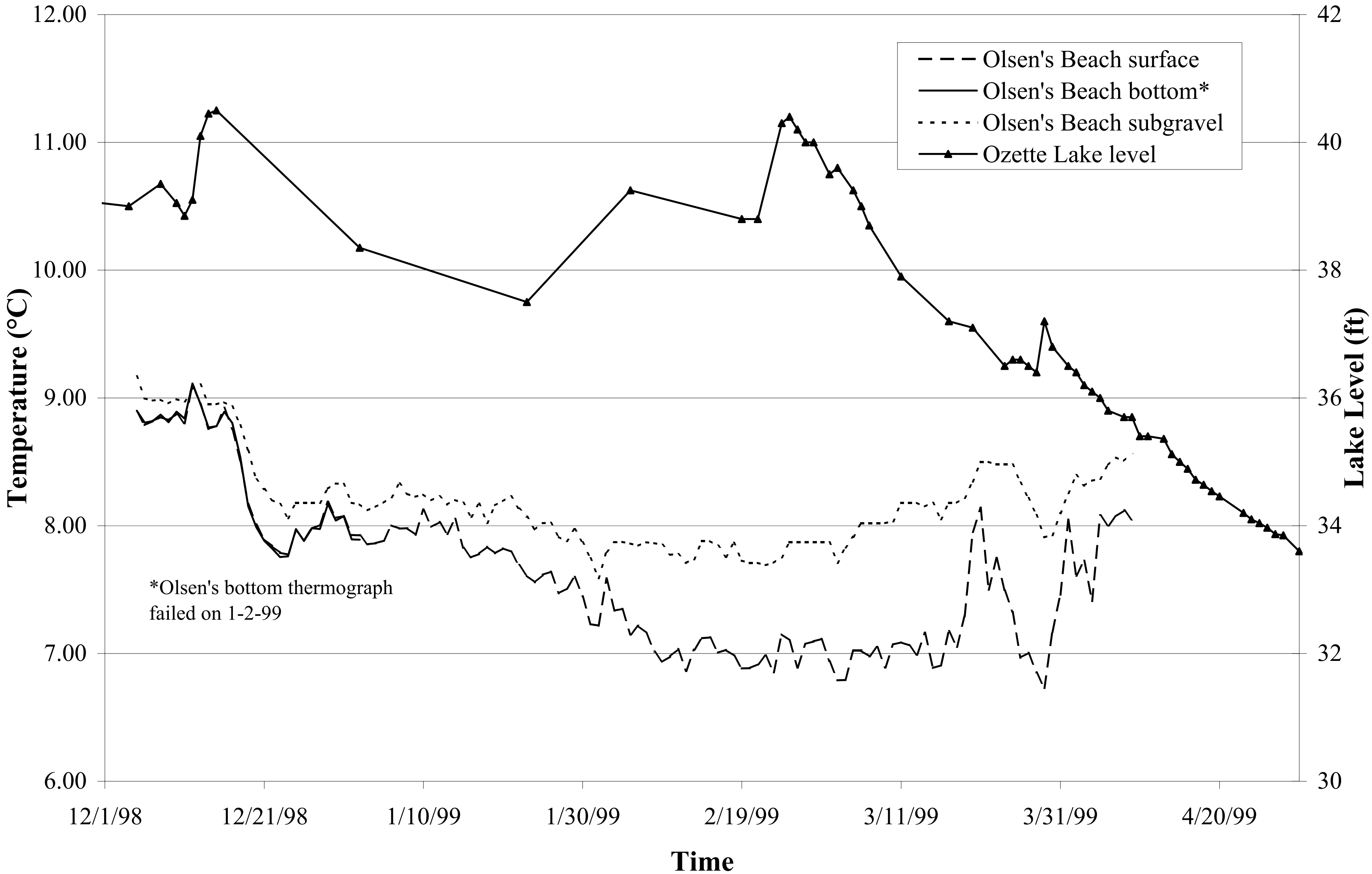

Figure 22. Winter 1998 to Spring 1999 Olsen's Beach water temperatures and Ozette Lake level.

As can be observed, the temperatures of the subgravel (7.9 ± 0.04 °C; n = 126) and above gravel (mean 7.5 ± 0.05 °C; n = 127) thermographs at Allen's Beach were very similar (mean difference 0.4 °C). The temperatures of the subgravel (8.4 ± 0.09 °C; n = 29) and above gravel (mean 7.6 ± 0.05 °C; n = 127) thermographs at Olsen's Beach were also very similar for the month that they could be compared (mean difference 0.8 °C).

The mean daily water temperatures were compared among both beaches and the Umbrella Creek Hatchery from Winter-1998 to Spring-1999 (Figure 23). Mean water temperatures were slightly colder at Allen's Beach (7.3 ± 0.05 °C; n = 127) than at Olsen's Beach (8.2 ± 0.03 °C; n = 126; mean difference 0.9 °C) but both remained fairly stable ranging from 6.4 °C to 9.2 °C. Water temperature at the Umbrella Creek Hatchery (mean 5.7 °C ± 0.12 °C; n = 121) and the ambient water temperature of Umbrella Creek (mean 5.7 ± 0.14°C; n = 112) were cooler than the lake beaches (mean difference ~ 2 °C) and fluctuated considerably more. Currently, thermographs are placed on sockeye redds on both spawning beaches and on upwelling springs and seeps on both spawning beaches (below and above gravel and within the water column) in addition to Umbrella Creek and rearing facilities.

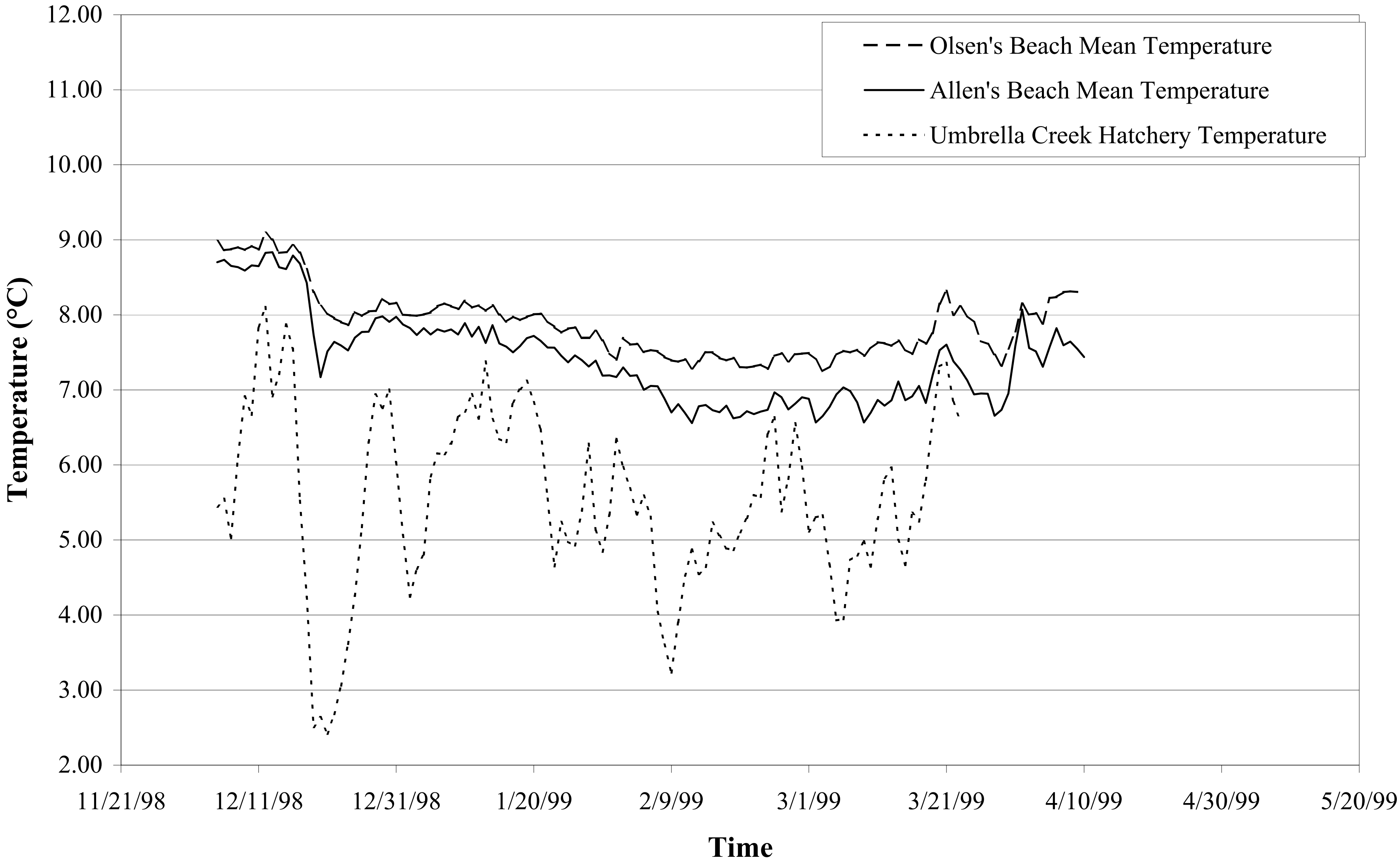

Figure 23. Winter 1998 to Spring 1999 comparison of Olsen's Beach, Allen's Beach, and Umbrella Creek Hatchery daily mean water temperatures.

Very little historical temperature data exists for the Educket facility, which overlaps temporally with Umbrella or MNFH data. While no direct temperature comparisons can be made, there is uncalibrated thermograph data from November 4, 1991 to March 26, 1992, (mean = 7.5 °C ± 0.09 °C, n = 144) and from November 1, 1993 to January 10, 1994 (mean = 6.5°C ± 0.18°C, n = 70). These temperatures are noticeably warmer than the MNFH and Umbrella temperatures, and correspond much more closely to Lake Ozette water temperatures. This is not surprising, since the Educket Hatchery water source is the Educket Reservoir, while Umbrella and MNFH sources are both streams.

Using the average between Allen's (7.3 °C) and Olsen's Beaches (8.2 °C) to get a mean lake beach temperature of 7.85°C, the mean water temperature at Umbrella Creek and the Umbrella Creek Hatchery (also mean 5.7 °C) were compared (Table 8). Since the mean temperature at Educket was very similar or identical to the mean lake beach temperature and the temperature at MNFH was nearly identical to that of the Umbrella Creek Hatchery, their temperatures, TU's, and differences in temperature-dependent development rates may also be considered to be close to the same as the lake beaches and Umbrella Creek, respectively, as shown below. Using the temperature unit requirements measured by MFM for Lake Ozette sockeye eggs (Table 11) to achieve eye up (500 TU's), hatching (1,000 TU's), and swim up (1,400 TU's), the number of days required to reach different stages of development were compared between the lake beaches and the tributaries (Table 8).

Table 8. Comparison of incubation temperatures, accumulated temperature units, and time to reach various stages of egg development.

	Mean Daily Temp (°C)	Mean Daily Temp (°F)	TU's	Daily TU Differential	Days To Eye Up	Eye up Diff. (Days)	Days To Hatch	Hatch Diff. (Days)	Days To Swim Up	Swim Up Diff. (Days)
Lake Beaches	7.9	46.1	14.1	0.0	35	0	71	0	99	0
Umbrella Creek and Umbrella Creek Hatchery	5.7	42.3	10.3	3.8	49	14	97	26	136	37

While eggs incubated in Umbrella Creek, the Umbrella Creek Hatchery, or MNFH were projected to eye up within two weeks of eggs incubated on the lake beaches, hatching and emergence in Umbrella Creek, the UC Hatchery, or at MNFH were projected to be later than on the lake beaches by more than three weeks and five weeks, respectively.

Incubating eggs at the Educket Hatchery may minimize any differences in development due to its similar temperature regime to the lake. Eyed egg plants from any of the facilities will minimize the delay in development to no more than two weeks. Swim up in fry originating from Umbrella Creek and the Umbrella Creek Hatchery has been observed to occur at the same time as natural coho and sockeye salmon, which originate in tributaries and emigrate to the lake as swim up fry. While development is expected to be more than three weeks later for hatching and more than five weeks later for swim up in fry originating in Umbrella Creek, the Umbrella Creek Hatchery or at MNFH, than for fry originating from eggs deposited at the same time on the lake beaches, the range of spawning and consequent emergence in the lake spawning aggregations (lake spawning has been observed during, and as much as 2 to 2.5 months later than spawning has been observed in Umbrella Creek in recent and in past years), remains within the same emergence window for fry originating in Umbrella Creek.

If lake and Umbrella Creek fry spawn at the same time, feeding may compensate for their later hatching; however, monitoring of the natural and hatchery fry outmigration into the lake from Umbrella Creek in 1999 suggested that there may be other environmental factors and life history traits to consider in assessing the best release strategy. River flows were not as conducive to egression of hatchery fingerlings planted in June as they were when the natural salmonid fry emigration occurred in April and early May, 1999. Most of the natural emigration occurred during higher flows during freshets, which had essentially subsided by June in 1999. These higher flows, combined with a potentially higher genetic predisposition toward negative rheotaxis that is more conducive to outmigration in swim up fry than in fingerlings, were presumed to facilitate fry outmigration. It may be that hatchery fingerlings planted in June, when sockeye fry in Lake Ozette are not emigrating and have taken up their lake residence, may not exhibit the same disposition nor the same intensity to outmigrate when stream flows are lower in the summer and they are no longer at the fry life stage when juvenile sockeye typically migrate to their nursery lakes.

While much of the literature has purported the optimal size at release for chinook and coho to be at the larger smolt size, smolt or even fingerling releases may not be optimal for Lake Ozette sockeye when sockeye life history and stream flows in the Ozette Basin are considered. Reintroduction efforts beyond Umbrella Creek will require egg plants to prevent imprinting problems. Further research on optimal stage of development at release for Lake Ozette sockeye is needed and must consider the interaction between environmental factors, such as stream conditions and sockeye life history factors in consideration of genetic rheotactic predisposition to emigrate and imprinting concerns, which depend on the planting site, relative to choosing egg plants, swim up or fed fry releases, or fingerling releases. Monitoring the post-release survival of differentially marked release groups will determine the optimal strategy for all release sights. Differences between fry and fingerling dispositions to emigrate and orientation differences toward current direction in Umbrella Creek were observed in 1999 monitoring when fyke net captures of hatchery fish resulted in only 33% of fingerlings released (Figure 25).

SECTION 4. FACILITIES

Provide descriptions of the physical plants listed in this section, and three additional sets of information.

One, for programs that directly take listed fish for use as brood stock, provide detailed information on catastrophe management, including safeguards against equipment failure, water loss, flooding, disease transmission, or other events that could lead to a high mortality of listed fish.

Two, describe any instance where construction or operation of the physical plant results in destruction or adverse modification of critical habitat designated for the listed species.

Three, describe any inconsistencies with standards and guidelines provided in any ESU-wide hatchery plan approved by the co-managers and NMFS.

4.1) Brood Stock Collection Facilities:

N/A

4.2) Spawning Facilities:
Umbrella Creek Hatchery:

<u>Physical description and risk management :</u>

The Umbrella Creek Hatchery is located adjacent to the confluence of WRIA tributary #20.0056 and Umbrella Creek at RM 4.5. The adult holding and spawning facility at Umbrella Creek Hatchery is equipped with two 300-ft3 circular fiberglass tanks. These tanks are sited within a 24 ft x 48 ft open-sided building.

Catastrophe Management (safeguards against equipment failure, water loss, flooding, disease transmission, or other events that could lead to a high mortality of listed fish):

Past procedures causing brood stock mortalities have been corrected or discontinued. Brood stock losses in the past were primarily due to cage and net pen holding mortalities prior to 1991, which have been permanently discontinued and are not associated with the current program, which houses brood stock at the Umbrella Creek Hatchery. Since holding began at Umbrella Creek, brood stock mortalities were caused when insufficient staff was available to monitor the facility. A freshet in 1997 caused the intake pipe to become clogged and in 1995, losses were mainly attributed to jumping mortality when tank lids were left uncovered. Tank lids remain on all tanks housing brood stock and safeguards against equipment failure and water loss due to flooding include the hiring of additional full time permanent hatchery staff dedicated to monitoring and maintenance of listed fish under culture. Individual staff are assigned to each of three different facilities and are available to back up at other facilities. Daily monitoring has been increased during the brief periods when brood stock are held (one day up to three weeks) and hatchery staff may be housed on premises 24 hours per day during freshets if deemed necessary. Additionally, MFM is in the process of installing backup oxygen and an alarm system comprised of a float switch installed on the water inflow line connected to a sattelite telephone system alarm system to ensure that fish remain safe and that hatchery staff are immediately advised of any water interruptions that may occur.

Adaptive management to reduce potential risks associated with losses due to disease or water failure resulted in moving all eggs from spawners to the Educket isoincubation facility in 1999/2000 and 2000/2001 and includes plans to incubate eggs at the Makah National Fish Hatchery (MNFH) isoincubation quarantine building beginning in 2001/2002. Besides isoincubation, iodophor disinfection of eyed eggs, in addition to green eggs, will further reduce the potential for disease transmission back to Umbrella Creek. Close proximity to hatching will be avoided to prevent damage to eyed eggs from iodophor disinfection. All fish culture and transfer activities will comply with co-manager fish health policies.

Instances where construction or operation of the physical plant results in destruction or adverse modification of critical habitat designated for the listed species:

N/A. Critical habitat for Lake Ozette sockeye is not affected by operation of any of the hatchery facilities.

Inconsistencies with standards and guidelines provided in any ESU-wide hatchery plan approved by the co-managers and NMFS:

This hatchery plan, combined with the habitat plan previously described, is a component of the ESU-wide Lake Ozette Sockeye Recovery Plan under development for Lake Ozette sockeye.

4.3) Incubation Facilities:

Although egg losses due to facility failure or disease have not occurred, a loss did occur in hatching fry in 1993 due to an epizootic caused by Infectious Hematopoietic Necrosis (IHN) disease. The source of infectious IHN virus causing the epizootic was presumably from infected eggs from gametes of parents, which had a 100% incidence of IHN virus in 1992, to offspring; and not due to fish to fish transmission, because no salmonids were observed in the tributary water source to the facility nor below the facility in this tributary. Instead of returning to the facility, sockeye currently spawn in Umbrella Creek in areas that are, at a minimum, approximately 0.5 miles from the facility. Spawning in Umbrella Creek was completed more than two months prior to when the spring 1993 outbreak occurred in swim up fry. To prevent the possibility of another IHN epizootic, we will utilize two isoincubation quarantine facilities to incubate eggs for this stock. In addition to isoincubation, iodophor disinfections of eyed and green eggs (previously only done on green eggs) will occur to further reduce disease risk potential.

Also, to successfully otolith mark eggs which is required for subsequent monitoring necessary to identify and reduce risk, it is necessary to incubate the eggs at facilities where electricity and generators are available to power chillers and heaters. These are required to deliver adequate changes in water temperature to give distinguishing thermal otolith marks (Attachment 3, Section 12).

Despite applying for this badly needed funding to mark otoliths as required to monitor the fish, the Makah Tribe's request for otolith funding was not accepted although the genetic study portion of the grant application described in Attachment 2 was funded by the HSRG. In spite of this lack of funding for otolith marking, the Tribe paid more than $10,000 in brood years 1998 and 1999 to mark fish, collect samples, have otoliths read, and to provide equipment for otolith marking such as generators, electrical wiring, chillers or heaters, and other equipment. Future hatchery reform monies are supposed to become available for this desperately needed monitoring. Support from NMFS to the HSRG to fund Lake Ozette sockeye otolith monitoring work in the future is needed and greatly appreciated.

Educket Isoincubation Hatchery (1999/2000 and 2000/2001):

<u>Physical description and risk management:</u>

The Educket Reservoir serves as the primary water source for the community of Neah Bay. The Educket Creek Hatchery, located at the base of the Educket Reservoir, was renovated in 1990-91. The renovation included the installation of a 1,500 ft^3 fiberglass head tank, a 10 foot x 14 foot insulated metal incubation building with a chlorinated effluent disinfection system, and a 500 ft^3 fiberglass raceway.

Water is supplied to the incubation system via a tap to the municipal raw water supply manifold from the reservoir. The water is introduced at the top of a 20-foot-tall head tank and exits the head tank via a schedule 80, four-inch PVC pipe, offset four feet above the base of the head tank. The overhead, four-inch, PVC plumbing manifold within the incubation building supplies either of two egg incubation systems. Three back up water supplies are available as: gravity feed from the reservoir via an existing two-foot diameter pipe which can be retrofitted to provide inflow to the head tank, and from water pumped from the 500 ft^3 fiberglass raceway.

The sockeye egg isoincubation system currently in use is patterned after the successful isolation incubation system utilized for the endangered Redfish Lake sockeye program located at the Big Beef Creek Hatchery on Hood Canal. The Educket isoincubation system is also a down-welling bucket system housed within a standard 16-tray Heath/FAL vertical stack incubator, 69-

inches (1,75.3 cm) high x 23 ¾-inch (60.3 cm) wide x 25 inch (63.5 cm) deep. Each unit is designed to hold the fertilized eggs of a single female sockeye. Each down-welling bucket component includes: a ½-gallon high density polyethylene (HDPE) bucket with bottom replaced by an eighth-inch square mesh vexar screen, a pair of polyethylene spacers, a polyethylene water diffuser, and a solid bottom HDPE bucket. The water supply for each of these units is delivered at a rate of six gallons per hour through a drip irrigation manifold. The manifold for each vertical stack consists of five ¼-inch polypropylene feeder lines for each of six, ½-inch polypropylene mainlines. Each mainline is valved with a ½-inch pvc ball valve threaded to a ½-inch pvc feeder pipe. Each feeder pipe is connected to a one-inch pvc branch connected to a two-inch pvc sub-main connected to the four-inch overhead main. This configuration provides a maximum of thirty isoincubation units per stack for each of the three incubator stacks.

The use of isolation incubation units will enable tracking and quarantine of eggs from individual females. Because the adult fish health certification sampling is conducted at the individual fish level, we will retain maximum flexibility to segregate eggs according to the results from the adult fish health monitoring provided by the Northwest Indian Fisheries Commission (NWIFC) Fish Health Laboratory (Craig Olsen, pathologist) or beginning in 2001, by the U.S. Fish and Wildlife Service Disease Laboratory in Olympia, Washington (Ray Brunson, pathologist). Once the eggs have attained the eyed stage, up to four isoincubation units will be consolidated into a single Heath/FAL incubator tray based upon their parental disease history status.

A series of WDFW programmed otolith marks will be induced upon the eyed eggs in each tray by manipulating their water temperature. Water temperature regimes will be manipulated by moving the trays of eggs between Heath/FAL stacks supplied with either heated or ambient temperature water. The water will be heated by passing it through a pair of 220 volt, 6000-watt stainless steel inline water heaters installed on a single Heath/FAL stack. Although the maximum temperature possible for these heaters under the programmed 4 gpm flow regime is only 12^0 Fahrenheit, the electrical output of the heaters will be controlled by a digital heater control unit. The electricity for the heater units will be supplied with a trailer mounted 25 kW diesel generator.

Catastrophe Management (safeguards against equipment failure, water loss, flooding, disease transmission, or other events that could lead to a high mortality of listed fish):

Safeguards to prevent mortality of listed fish at Educket Hatchery include:

- ♦ Prevention of cross contamination/horizontal transmission of infectious fish pathogens by isoincubating eggs to the eyed stage and by segregating/quarantining each egg lot until fish pathogen diagnostic results are in and throughout incubation at this facility.
- ♦ Improvement of ability to monitor and evaluate, and assess risk by greatly improving the proximity to Makah Fisheries Management personnel.
- ♦ Improvement of facility with new plumbing, equipment, isoincubators, including disinfection of effluent, and operation of a generator to ensure the ability to otolith mark during winter power outages.
- ♦ Improved water quality, particularly suspended fine sediments and improved stability of water source[1]. The water source at Educket has been determined to be pathogen free. It is the reservoir supplying the Tribe's water supply, which is more stable than the tributary water

1. The stability of this reservoir water supply was critical to maintaining high incubation survival during and after the December 15, 1999, catastrophic flood. Green to eyed egg survival of all three egg takes that were in culture at the Educket facility ranged from 94% to 98%.

source to Umbrella Creek Hatchery. This reduces the possibility of losses due to intake screens clogging or the possibility of losses due to egg suffocation from excessive siltation. Even though egg losses have not occurred due to water flow or sediment problems in the past at Umbrella Creek for this program, they have been known to occur in other facilities.

- Iodophor disinfection of eggs prior to transferring eggs to and from the facility greatly reduces the possibility of vertical transmission of infectious fish pathogens.
- Transfer of eyed eggs to planting sites prior to hatching further greatly reduces the likelihood of an IHN epizootic since outbreaks occur after hatching.
- Effluent disinfection and survival monitoring eliminates the possibility of horizontal transmission of any potential disease organisms from the quarantine building to areas downstream from the facility.
- Egg planting reduces domestication and other non-genetic influences of the artificial hatchery environment and increases production potential at MNFH because less water is needed for egg incubation than to rear fry.
- Isoincubation and separation allows for segregation of families for preservation of gene pool variability and maximizes the number of crosses that can be represented in subsequent releases.

Instances where construction or operation of the physical plant results in destruction or adverse modification of critical habitat designated for the listed species:

N/A Critical habitat for Lake Ozette sockeye is not affected by operation of the hatchery.

Inconsistencies with standards and guidelines provided in any ESU-wide hatchery plan approved by the co-managers and NMFS:

This hatchery plan, combined with the habitat plan previously described, is a component of the ESU-wide Lake Ozette Sockeye Recovery Plan and Tribal Resource Management Plan under development for Lake Ozette sockeye.

Makah National Fish Hatchery (Beginning Winter 2001)

Physical description and risk management:

The Makah National Fish Hatchery (MNFH) is a United States Fish and Wildlife Service (USFWS) federal government hatchery located on the southwest bank of the Sooes River on Makah Reservation lands, approximately three miles upstream of the river mouth. The water intake supply, from the Sooes River, is pumped (approximately seven cfs) by one to two of the six 50 to 100 hp river pumps to a large sedimentation settling basin located at an elevation above that of the hatchery rearing vessels. Water from the settling basin is pumped through a series of five sand filters. Filtered water will be pumped via a two-inch line to the isoincubation quarantine building.

A detailed description of the MNFH isoincubation quarantine building, which will be used to incubate Lake Ozette sockeye eggs, including schematic drawings, has been completed by the USFWS (Planning Study report: Egg Isolation Facilities; Makah National Fish Hatchery 1988). Construction of the quarantine building is approximately 80% completed. The building structure is finished and ambient processed water is expected to be plumbed to the building between the latter months of 2000 through the first the first half of 2001. Also, a year-round non-filtered water supply will also be plumbed to the quarantine building during this period. Water inflow rate will be targeted at 60 gpm. Inflow will be single- or preferably double-sand-filtered. Filtered inflow water will be single- or preferably double-UV-treated. Flows will be controlled by a float valve to maintain a prescribed level inside the gravity inflow head box which will be equipped with a flow sensor alarm system. The main facility, on pumped Sooes River water, already has an alarm system and staff housed on premises. An alarm system is needed to be installed in the inflow water head box in the quarantine building.

The inflow system will be equipped with heating and chilling capability for 50 gpm, downstream from the float valve, to enable thermal egg mass marking. A supply tank and recirculation of unused inflow water will ensure adequate heating/chilling. Cost estimates for each of these systems are being completed. This water will flow from a stainless steel or fiberglass head box through two-inch PVC lines to four troughs. The building will be plumbed for isoincubation. The overall goal will be to plumb in 150 isobuckets; however, initial plumbing may only include 50 isobuckets. Schematic drawings and space considerations will be completed in advance to evaluate the capability of plumbing 150 isobuckets. Flows to individual bucket incubators will be regulated by controllers from drip irrigators installed on the two-inch pipe and carried by plastic tubing to the buckets.

Egg isolation buckets will be comprised of two 3-1/2 gallon plastic buckets. Water will downwell through the eggs at a rate of 0.1 gpm. The incubators will be housed inside four fiberglass troughs.

Effluent will be chlorinated to ensure adequate contact time in the sump to provide 2 ppm residual sodium hypochlorite in the effluent, within EPA allowable limits on the reservation. MNFH staff will monitor the system.

Catastrophe Management (safeguards against equipment failure, water loss, flooding, disease transmission, or other events that could lead to a high mortality of listed fish):

In 1999, a multi-agency (USFWS, NWIFC, MFM, and WDFW) disease sub-panel evaluated disease risks of using the Makah National Fish Hatchery (MNFH) to incubate eggs to the eyed stage beginning in 2000. The panel conferred on 6/29/99 and 6/30/99 and reached consensus that use of MNFH would be a net benefit to the ESU in terms of fish health and would reduce risk associated with potential loss due to disease if certain precautions are undertaken. Changes to the Future Brood Document have been submitted to accompany the proposed change in source of brood stock from lake - to tributary – origin. Specific concerns that were evaluated by the subpanel relating to operation of the facility and fish health management follow:

Filtered inflow water will be single or preferably double UV-treated. This will be very important to prevent the exposure of sockeye eggs to pathogens. Without this precaution, the finding of a regulated viral pathogen in the Sooes River system could prevent the return of the eggs to the Ozette system. The gravity inflow head box will have a flow sensor alarm system. The main facility, on pumped Sooes River water, already has an alarm system and staff housed on premises.

Gametes will be collected from green adults that are held until spawning at the Umbrella Creek Hatchery. Once spawned, sperm from each spawner will be retained in labeled plastic bags under oxygen and eggs will either be held in separate, closed, plastic containers or in bags in coolers above, but insulated from, ice to keep them very cool but to not freeze them during transport. While it is anticipated that most adults will be captured by trap for the tributary program, gametes and tissue samples from ripe adults may also be collected riverside, retaining eggs and sperm from each spawner as previously described. Unfertilized gametes will be tranferred above ice in a cooler insulated from direct contact with ice during transport to the isoincubation facility where random pair selection, fertilization, and disinfection of the fertilized eggs will take place. Tissue samples from each adult, male and female, will be individually sampled and tested for the presence of certain infectious fish pathogens. Unfertilized green eggs and milt will be labeled correspondingly to identify parents that contributed gametes to the matrix spawning for each isobucket.

Since construction of the MNFH isoincubation quarantine will not completed by fall of 2000, eggs will be incubated an additional year at the Educket isoincubation facility. Fertilized eggs will be mixed and rinsed with an iodophor solution, then mixed and rinsed again with a 100 ppm iodophor solution, then water hardened in another separate 100 ppm iodophor solution for one hour.

When fish pathogen diagnostic results are in, an adaptive management approach will be taken to determine management actions for the disposition of eggs prior to transfer to Umbrella Creek, based on the results of pathogen testing of adults. Management actions for the disposition of fry once transferred to Umbrella Creek will be based on the results of their pathogen testing. No eggs will hatch at MNFH. Adaptive management decisions concerning the disposition of eggs resulting from tissues testing positive from one or more parents will be made based upon recommendation by the disease sub panel which is represented by USFWS, NWIFC, WDFW, and MFM.

Based on a risk assessment, which will consider factors such as infection rate, titer, type of pathogen, outplanting strategy, and other factors, the panel may recommend to segregate or cull high risk egg lots. If clinical IHN disease is detected in fry, the panel will likely recommend that infected lots be destroyed.

As one example: if IHNV is detected in parents, the incidence and titer would be considered. If only one or so fish are found positive or if mortality due to IHN is observed, the progeny may be culled or at minimum, quarantined; however, the risk associated with the likelihood of clinical disease in eggs from parents testing positive for IHNV following iodophor disinfection would need to be weighed with potential survival benefits. The disease sub panel may decide to euthanize clinically diseased fish, particularly those experiencing high mortality from IHN, based on the risk analysis. However, it is unlikely that they will recommend destruction based solely on the results of the adult testing.

When eggs become eyed, they will be otolith marked, disinfected with 100 ppm iodophor, and removed from MNFH or Educket for outplanting or for hatching and imprinting at Lake Ozette. Continuing to provide a virus-free water supply is critical for hatching and rearing fish within the Ozette system to prevent a loss of fish due to IHN.

Coordination between relevant co-managers is required to ensure that all proper permits are acquired. Two changes of program request have been submitted to WDFW and appropriate changes to the Future Brood Document were made to accommodate these transfers.

Risk Assessment for using MNFH to isoincubate Lake Ozette sockeye eggs:

Benefits to the ESU:

(a) Reduces the potential for cross contamination/horizontal transmission of infectious fish pathogens by isoincubating eggs to the eyed stage or by isoincubating eggs until fish pathogen diagnostic results are in.

(b) Improves ability to monitor and evaluate, and assess risk: Greatly improves proximity to USFWS and MFM personnel.

(c) Further reduces the possibility of loss due to water limitations and failures through improvement of facilities. MNFH is a new facility with new plumbing, equipment including UV disinfection of influent and effluent, alarm system, and isoincubators

(d) Increases potential for production through increased water inflow capacity needed for isoincubation and for overall increased production.

(e) Improves water quality, particularly suspended solids and siltation. The MNFH water source currentl has a settling pond and sand filtration. It is anticipated that this water supply will also undergo cartridge filtration before it runs through the UV disinfection system prior to entering the isoincubation quarantine building. All of these settling pond and filtration systems reduce the possibility of losses caused by water interuptions from intake line obstructions or the possibility of losses due to egg suffocation from excessive siltation. Although egg losses have not occurred at the Umbrella Creek Hatchery due to inflow failure or excessive sedimentation, they have been known to occur in other facilities. Moving the eggs to a more secure facility at Educket Hatchery averted mortality that may have occurred at Umbrella Creek Hatchery due to disastrous flooding that occurred on December 15, 1999.

(f) Iodophor disinfection of eggs upon transfer to MNFH will greatly reduce the possibility of vertical transmission of infectious fish pathogens.

(g) Transfer of eyed eggs to planting sites prior to hatching further greatly reduces the likelihood of an IHN epizootic since most outbreaks occur after hatching.

(h) Effluent disinfection and survival monitoring would greatly reduce or eliminate the possibility of horizontal transmission from the quarantine building to areas downstream from the facility. Horizontal transmission of IHN virus from eggs to fish has not been reported, particularly in disinfected effluent from incubating, disinfected eggs.

(i) Isoincubation and separation allows for segregation of families for preservation of gene pool variability and maximizes the number of crosses that can be represented in subsequent releases.

Risks to the ESU:

(a) Potential non-genetic risks by altering natural spawning and incubation conditions. Tom Flagg and Conrad Mahnken of the NMFS in Manchester, Washington evaluated ecological concerns over potential early imprinting prior to hatching that might lead to straying. These scientists determined that imprinting and subsequent straying were not a significant concern as long as the eyed eggs were moved back to Ozette prior to hatching. The temperature regimes at the two facilities were nearly identical (Figures 18 and 19). Water temperatures at MNFH (mean $6.4 \pm 0.1°C$; $n = 121$) were slightly warmer than at the Umbrella Creek Hatchery (mean $5.7 \pm 0.1°C$; $n = 121$). The average daily difference (MNFH – Umbrella Creek Hatchery), compared between the two facilities, was only $0.8 \pm 0.1°C$; $n = 121$.

As previously discussed in Section 3, hatching and emergence in the tributaries, Umbrella Creek Hatchery, and MNFH is presumed to occur later but within the time window of hatching and emergence on lake beaches and at the same time as that of healthy and growing coho and sockeye NOR spawning aggregations in Umbrella Creek and in other tributaries to the Basin. Hatching and emergence at the Educket Hatchery is presumed to occur at nearly the same time as hatching and emergence in the lake due to their similar temperature regimes. Any delays in hatchery reared fish might be mitigated by increased development from feeding during early rearing; however, life history and environmental changes associated with later releases of fed fry or fingerlings must be weighed against any perceived benefits, by evaluating different release strategies. Any beach plants that occur will be done as eyed eggs, which will minimize differences in development to no more than two weeks.

(b) Disease risks by altering the natural spawning and incubation conditions. These should be reduced because isoincubation and quarantining will be employed and because the eggs are already being held in a hatchery.

(c) Water failure risks are always possible in hatcheries, as are possible equipment failures during transport.

Risks to MNFH:

(a) Potential introduction of fish pathogens to the hatchery fish populations. The Ozette sockeye are known to be susceptible to IHN virus.

These benefits and risks have been discussed with MNFH Hatchery Management, and USFWS Production Managers, and Pathologists.

Genetic Risks of Using MNFH for Lake Ozette Sockeye Salmon Egg Incubation:

Ken Currens, geneticist for the Northwest Indian Fisheries Commission, performed the following genetic risk assessment. He determined that use of Makah National Fish Hatchery (MNFH) to incubate eggs to the eyed stage, rather than Umbrella Creek, does not appear to pose increased genetic hazards, as long as effects on imprinting do not lead to increased straying.

A qualitative assessment of the risks suggests that potential risk of extinction and loss of within-population diversity may be decreased by using Makah National Fish Hatchery. The risk of domestication is unknown. We know too little about the expected course of domestication to make a good assessment.

Extinction

Risk of extinction might be expected to increase if survival at MNFH were so low that fish being used as brood stock were not replacing themselves. We have no reason to expect that this would be the case. In contrast, the improvement in facilities and increased proximity to staff should decrease risk of catastrophic failures causing large losses of fish due to facility failures or to a disease epizootic.

Loss of Diversity Among Populations

Loss of differences among populations, subpopulations, or spawning aggregations could occur if imprinting on MNFH water during incubation resulted in increased straying and gene flow. However, early imprinting concerns evaluated by NMFS staff in 1999 at MNFH relative to straying were considered minimal as long as the eyed eggs were outplanted from MNFH prior to hatching.

Loss of Diversity Within Populations

Risk of loss of genetic variation among individuals within a spawning aggregation would increase if the move to MNFH resulted in a smaller effective population size. We have no reason to expect this would occur. Spawning practices would be unchanged or improved. Improvement in facilities and increased proximity to staff should decrease risk of catastrophic failures in the facility and the decreased risk of large losses of fish should help maintain effective size of the hatchery component. Likewise, we have no reason to expect an increase in the variance of family size.

Domestication

Risk of domestication would increase if the incubation environment at MNFH resulted in increased nonrandom mortality of eggs or if the mortality occurred over a longer period of the life history of the fish. At this point, we know too little about the nonrandom mortality at MNFH or Umbrella Creek to speculate on potential differences. In either facility, the eggs would be held for the same amount of time. The improvement in facilities, however, should allow for improved water quality during incubation including disinfection of influent and effluent and will allow for otolith marking, which is critical to determine postrelease survival.

Instances where construction or operation of the physical plant results in destruction or adverse modification of critical habitat designated for the listed species:

N/A Critical habitat for Lake Ozette sockeye is not affected by operation of the hatchery.

Inconsistencies with standards and guidelines provided in any ESU-wide hatchery plan approved by the co-managers and NMFS:

This hatchery plan, combined with the habitat plan previously described, is a component of the ESU-wide Lake Ozette Sockeye Recovery Plan and Tribal Resource Mangement Plan.

4.4) Rearing Facility:

Umbrella Creek Hatchery

Physical description and risk management:

The Umbrella Creek Hatchery is located adjacent to the confluence of WRIA tributary #20.0056 and Umbrella Creek at RM 4.5. The hatchery water supply consists of a 20 ft x 4 inch PVC well screen located in tributary #20.0056 in an impoundment pool formed by a low head gabion dam located 200 yards upstream from the facility. The hydraulic head differential between the infiltration system and the hatchery building provides approximately one cfs of gravity-fed surface water via a heavy-walled, six-inch, high-density, polyethylene supply pipe to the hatchery. The rearing vessels include four 48 ft^3 shallow fiberglass starter tanks, and two 300 ft^3 circular fiberglass tanks. These rearing vessels are sited within a 24 ft x 48 ft open-sided building.

Catastrophe Management (safeguards against equipment failure, water loss, flooding, disease transmission, or other events that could lead to a high mortality of listed fish):

Safeguards against equipment failure or water loss have included hiring additional full time permanent hatchery staff dedicated to monitoring and maintenance of listed fish under culture at the Umbrella Creek Hatchery. A total of three additional staff are available as back up to the two staff assigned to this facility. Daily monitoring has been increased during periods of heavy rain and hatchery staff may be housed on premises 24 hours per day during freshets if deemed necessary. Current efforts are also underway to obtain a backup oxygen system for holding tanks and a VHF radio/telephone alarm system at the Umbrella Creek Hatchery. Disease prevention safeguards previously mentioned will greatly reduce the possibility of future disease epizootics. Early planting with minimal rearing will reduce the potential for disease, domestication, and general exposure to the artificial environment.

Instances where construction or operation of the physical plant results in destruction or adverse modification of critical habitat designated for the listed species:

N/A Critical habitat for Lake Ozette sockeye is not affected by operation of the hatchery.

Inconsistencies with standards and guidelines provided in any ESU-wide hatchery plan approved by the co-managers and NMFS:

This hatchery plan, combined with the habitat plan previously described, are components of the ESU-wide Lake Ozette Sockeye Recovery Plan and Tribal Resource Management Plan currently under development.

4.5) Acclimation/Release Facilities:

Eyed egg plants allow for imprinting and acclimation to suitable habitat in the new planting sites. Fry plants are restricted to Umbrella Creek and allow newly-hatched alevins and fry to acclimate to the same water source targeted for their return. Future hatching, fry acclimation, and rearing sites are being investigated on tributaries to Big River.

The equipment required to accomplish the various release strategies include remote site incubators (RSI's) and sufficient Jordan incubator units to accommodate egg plants. These incubators will be housed in five-unit blocks (2,000 eggs per block). Each 30 cm X 127 cm Jordan incubator is comprised of two opposing halves which fasten together in a sandwich fashion and house 200 plastic partitioned square cells (12mm X 12mm) for separate, quantifiable egg incubation. Alevins are allowed to exit via 0.5 cm holes leading to the outside from each partitioned cell. Multiple incubators may be fastened together in blocks. Plants used in this HGMP will employ blocks of five incubators (1000 cells). In 2000, incubators were grouped in three blocks of five and housed inside three trough type trout baskets, which allowed alevins to exit. Scuba divers planted these incubators in approximately seven feet of water on the outer boundary of spawning gravel on Olsen's Beach. Each basket was ballasted with two to three inches of 2.5-inch minus gravel. In addition, an eight-inch area surrounding the incubators was filled with one-inch Bio Rings® and everything was encased in heavy duty, 1/4 –inch vexar to prevent predation. Future lake plants will employ this method.

For the second year in a row, survival rates were high in the lake incubators (99% survival in 1999, 96% in 2000; see Monitoring Release under Section 10.4). The small size of the Jordan incubators allows seeding into small, remote areas and enables an estimate of hatching success upon recovery of the partitioned incubators post-hatching. Egg plants in the future that are intended for reintroduction (other than for small replicated experiments) may or may not use Jordan incubators depending on the number planted. Larger plants will occur inside larger incubators or the eggs may be planted into cleaned gravel using a pump and hollow cylinder to plant eggs into substrate. In addition, potential water sources and sites are under investigation for construction of remote site incubators. Egg planting equipment and methods remain under study.

Release equipment necessary for fry reintroduction includes a truck-mounted, 200-gallon transfer tank assembly employing a four-inch-diameter discharge flex hose to release fish directly from hatchery tanks to the nearby Umbrella Creek. The only equipment needed for Umbrella Creek Hatchery on-station fish releases is the same discharge hose used with the transfer tank.

4.6) Other:

N/A

SECTION 5. ORIGIN AND IDENTITY OF BROOD STOCK

5.1) Source:

List all sources of brood stock for the program.

The brood stock initially selected for reintroduction and supplementation in Umbrella Creek were taken from lakeshore natural spawning adults. However, as of the year 2000, a representative and appropriate number of NOR and hatchery origin returning adults to Umbrella Creek from the successful tributary reintroduction program will serve as the source of brood stock for future tributary operations. Using Umbrella Creek returns instead of beach spawners as the source of brood stock for tributary plants (strong feasibility with forecasted high run size in 2000 of 4,500 adult sockeye) will foster local adaptation and accelerate the tributary reintroduction component as well as reserve beach spawning fish for beach spawning production. In addition, from 2000 through 2003, we also propose to remove any adult sockeye that can be captured from Crooked Creek before they spawn if feasible. Reintroduction to this stream has been discontinued and removing these fish before spawning will reduce the potential for hybridization with kokanee. Additionally, this will foster more rapid colonization of natural spawners in Umbrella Creek by reducing removals of natural spawners. Guidelines to reduce genetic hazards or risks and implementation guidelines including numbers of NOR and hatchery tributary brood stock to collect were calculated by Dr. Ken Currens, a geneticist from the Northwest Indian Fisheries Commission in Lacey, Washington:

Brood Stock Collection Guidelines

Hazard	General Guideline	Explanation
Extinction	Brood stock collection should not compromise the sustainability of natural production that has begun in Umbrella Creek. This means that at low densities, NRR > 1.	The goal is to rebuild natural production in the tributaries.
Loss of among-population diversity	Limit brood stock numbers to avoid producing more adult returns than the tributaries can support.	Over-escapement may reduce reproductive success. This will be monitored and can be addressed by using excess fish for reintroduction to other under-seeded river segments in Umbrella Creek and Big River and by reducing or terminating tributary releases as these targeted streams become fully seeded.
Loss of within-population diversity	• Maintain variance effective size (N_{eV}) • Maximize inbreeding effective size (N_{eI})	Variance effective size is expected to increase in growing populations (Ryman *et al.* 1995). As long as natural production is self-sustaining (see guideline 1), decreases in N_{eV} should not be a problem. Inbreeding effective size is expected to decrease due to supportive breeding (Ryman and Laikre 1991), although the rate depends on the genetic effective size of hatchery fish and how well they contribute to the next generation.
Domestication (loss of fitness in the wild due to accidental or intentional selection for performance in the hatchery environment)	• Include natural origin recruits in the brood stock • Maintain self-sustaining natural production in the tributaries (see guideline 1); Operate the program for only short durations • Operate for short durations (3-5 generations).	Unpublished analyses (Ford *in prep.*) indicate that natural populations maintain self-sustaining reproductive rates in the wild if the proportion of natural fish in the brood stock is not less than it is in the total run, and if the duration of the program is short, changes in phenotypes due to selection in the hatchery will be minimal.

See implementation guidelines on following page.

Implementation Guidelines

1. Brood stock should be selected randomly and representatively from the total run, including natural origin recruits and hatchery origin fish.
2. For the first two to three generations, brood stock take for supplementation of Umbrella Creek only (not including brood stock collected for Big River egg plants) should be limited to no more than 15% of the expected annual run up Umbrella Creek, or 30-40 pairs of fish, which ever is smaller. This maximizes the total inbreeding effective size of the spawning aggregation.
3. For the first 2-3 generations, limit brood stock take to no more than 90-100 pairs from Umbrella Creek per year (for example when spawners from Umbrella Creek are to be introduced into Big River). This allows for growth of natural spawning aggregations in Umbrella Creek.

A small number of adult sockeye (approximately three females and one male per beach) will be collected and spawned in upcoming years to conduct small, replicated studies of limiting factors during egg incubation on their beaches of origin or in other suitable lake habitats. Between 50 to 100 fin samples (1 cm^2 caudal fin clip) will be collected for genetic analysis from carcasses from each beach, supplemented by samples non-lethally collected from live adults, targeting spawn outs, which will be subsequently released (Attachment 2).

Since the remnant lake spawning aggregations are currently known to spawn on two separate beaches, the potential that these beaches support two unique and distinct sup-populations must be determined. On both beaches, any future supplementation efforts, if deemed necessary, will employ an incremental approach, with experimentation occurring before supplementation on either beach to identify limiting factors. Only when it has been determined that supplementation efforts will likely aid recovery of the lake population, and that a successful method of supplementation exists, will the lake aggregations be used for reintroduction and/or supplementation measures in the lake.

Recent initial funding has been procured to conduct genetic analyses of samples already collected from the two spawning aggregations that are currently being held in an ultra-cold freezer at MFM. Samples include: 91 fin samples from adults not retained at Olsen's Beach in 1999, 28 duplicate samples of eye, muscle, heart, liver, and fin from adults retained for brood stock from Olsen's Beach in 1999, 8 fin clips from carcasses recovered from Allen's Beach in 1999, 138 fin clips of adults from Olsen's Beach in 1998, 27 fin clips of adults sampled from Allen's Beach in 1998, 56 fin clips from adult carcasses and spawn outs in Umbrella Creek in 1999, and 145 whole NOR sockeye fry retained from fyke netting in 1999. Adult samples collected in 1998 were not frozen but rather they were placed into a lysis tissue buffer solution for DNA analysis. Further genetic monitoring is scheduled for upcoming years under the direction of Dr. Ken Currens. Hybridization of the lake spawning aggregations will be avoided pending completion of the genetic analysis and until the relationship of these spawning aggregations is determined.

Segregation of the brood stock collected from each spawning location in tributaries and in the lake, coupled with the procedures outlined below, will maximize the ability of this HGMP to produce stocks which are genetically representative of the remnant native stock. The planting of eyed eggs from tributary spawners for reintroduction to Big River or from the beach spawners for reintroduction to other lake beaches, if demonstrated to be appropriate, will reduce ecological risks of supplementation by minimizing artificial impacts on selection through natural environmental mechanisms. This strategy will minimize the likelihood of straying by allowing newly hatched alevins to imprint on reintroduced habitat. Survival is expected to be increased through the use of hatchery methods above that of wild fish during fertilization and incubation through eye up, and by planting healthy eggs soon before hatching, any potential losses during egg incubation after planting, such as losses due to flooding, siltation, or predation, will be greatly minimized.

As shown in Table 8, eggs incubated at MNFH or Umbrella Creek would be expected to eye up at the same time as productive NOR sockeye and coho spawning aggregations in Big River and Umbrella Creek that outmigrate to the lake upon emergence and would eye up within two weeks of eggs incubated in the lake that were fertilized at the same time. Also, spawning time in the lake occurs before, during, and well after tributary spawning, which corroborates research (Beauchamp *et al.* 1985) that food reserves, which drive survival of emerging fry, are adequate over an extended period in this productive lake.

5.2) Supporting information:

5.2.1) History:

Provide a brief narrative history of the brood stock sources. For natural populations, specify its status relative to critical and viable population thresholds (use section 2.2.5 if appropriate). For existing hatchery stocks, include information on how and when they were founded, and sources of brood stock since founding. If stock crosses, list stock of each sex.

History: Artificial propagation in the Ozette Basin has not been extensive. The history of sockeye enhancement in the Lake Ozette system can be traced to a 1930's release of Baker River-origin fingerlings (U.S.F.W.S. records In Dlugokenski *et al.* 1981). In addition to earlier undocumented releases of Lake Quinault sockeye salmon fingerlings (Kemmerich 1945), 120,000 Lake Quinault stock sockeye salmon fingerlings were released into Lake Ozette in 1982.

Also (and unfortunately), five male sockeye were spawned from November 16 to 20, 1990, and 12 male sockeye were spawned from November 21 to 27, 1991, with an undetermined number of kokanee, producing 2,915 and 11,483 hybrid fry for release. These small kokanee/sockeye salmon hybrid releases probably had little or no effect on the genetic integrity of the ESU because these hybrids contributed less than 3% (1990) to less than 6% (1991) of the total fry estimated in the basin that year (Mike Haggerty, MFM, personnel communication). Moreover, survival of these hybrids was expected to be low and no adult hybrid returns were ever identified (Mike Crewson, MFM, personnel communication).

Despite these releases of other *O. nerka* stocks, it appears that none of these plants were successful and the genetic integrity of the stock identified as the ESU appears to be discrete and unaltered by the limited introductions from these other sources. This conclusion is based upon preliminary genetic analyses referenced in Gustafson *et al.* (1997) and the lack of any other sockeye population in the basin other than the known beach and tributary spawning aggregations.

Other than the release of Lake Quinault sockeye in 1982, the source of brood stock for this program has been natural beach spawning Lake Ozette sockeye salmon beginning in 1983. Further history on numbers of fish taken and the evolution of this program were previously discussed in detail in Sections 1.9 and 1.10.

Status relative to critical and viable population thresholds:

The following paragraphs (in the order presented) include a general defenition of viability, followed by a discussion of viability of reintroduced tributary spawning aggregations and overall runsize, ESA status, abundance, and productivity of tributary spawning aggregations, and research of parameters affecting the viability of beach spawning aggregations:

A viable salmon population is defined as one that has a negligible long term risk of extinction due to threats from demographic variation, environmental variation, or due to genetic diversity changes (McElhaney *et al*. 2000). Four predictors of viability or extinction risk have been identified and guidelines identified to indicate the performance of salmon populations, which may also be influenced by additional exogenous factors such as habitat or ecological interactions. The factors are: abundance, productivity, spatial structure, and diversity (McElhaney *et al*. 2000).

The status of the Lake Ozette sockeye ESU was previously evaluated in the Introduction relative to these four population performance measures where the reintroduction of sockeye salmon into the tributaries of Lake Ozette was examined for consistency with recovery guidelines under the NMFS application of the ESA. In this evaluation, the reintroduction of self-sustaining spawning aggregations in the tributaries was found to have positive effects on all four parameters. Moreover, this current draft HGMP proposes to utilize tributary returns for brood stock. This should end concerns over spawning aggregation mining of the lake donor stock for tributary plants. Also, the current focus to investigate limiting factors and continued monitoring of spawning aggregation abundance, trends, spatial distribution, and diversity of beach and tributary spawning aggregations will continue to provide the best means to identify the status and to evaluate the viability of the Lake Ozette sockeye ESU.

Abundance estimates, based on recent hard counts of adults entering the lake, as recorded by the new underwater video camera method, indicate that recent sockeye abundance is higher than ever previously reported. The average escapement to the upper Ozette River from 1996 to 1999 was 1,598 adults (range 1,133 to 2,076), with low year classes above 1,000 adult returns (Table 6). Although preliminary at this time, the 1997-2000 mean run size is projected to exceed 2,200 adult sockeye (MFM preliminary unpublished run size data). The 1977 to 1995 mean annual adult run size entering Lake Ozette from the Ozette River was reported to be 952 adults (Jacobs *et al*. 1996). Also using the run size figures in Jacobs *et al*. (1996), the mean run size from 1986 to 1995 was 851 adults, and the mean run size from 1977 to 1980 was 724. However, the reliability of run size estimates reported in Jacobs *et al*. (1996) is questionable, as previously described extensively in Section 2.2.2, and therefore, abundance trends will be unclear for several more years.

The actual 1999 return of approximately 2,076 adults was more than seven times higher than the expected return, based on the 10% rate of decline purported in the Federal Register (FR 63 11750) applied to run size estimates cited in Jacobs *et al.* (1996). These relatively large returns, and other recent findings regarding the errors and uncertainties in past abundance estimates, contradict the abundance and productivity estimates and subsequent concerns mentioned by NMFS in the Final Rules published in Federal Registers (FR 63 11750; FR 64 14528) that were based on the past data. For this reason, the status of the ESU, relative to critical and viable population thresholds, must be reevaluated. Historic abundance, productivity, spatial distribution, genetic and life history diversity of the population as a whole, as well as for individual spawning aggregations on lake beaches or in tributaries, is unknown.

Despite our lack of historical information on viability of the total run size or even recent accurate information on total run size prior to 1998, the currently employed video camera method has provided, by far, the most accurate estimates of total run size. Estimates of return levels to the watershed prior to 1998 can not be considered accurate due to the lack of consistent escapement survey data and methods, and because no precise data are available to estimate intercepting fishery exploitation rates for Ozette-origin sockeye, as previously described in great detail in Section 2.2.2. While both current and historical knowledge of the viability of lake spawning aggregations is lacking, current research is addressing this question.

The Lake Ozette sockeye salmon ESU was listed as "threatened" under the ESA of 1973 on March 25, 1999 (64 FR 14528). The listed sockeye salmon ESU includes all naturally spawned sockeye salmon residing below impassable natural barriers (e.g. long-standing, natural waterfalls) in Lake Ozette and its tributaries. Critical habitat was proposed in the Federal Register Notice as a final rule for the Lake Ozette sockeye salmon ESU on February 16, 2000 (FR 65 7764). Proposed critical habitat includes all lake areas and river reaches accessible to listed sockeye salmon in Lake Ozette. Sockeye salmon stock reared at the Makah Tribe's Umbrella Creek Hatchery are considered part of the ESU. When hatchery fish return and spawn in the wild, their progeny become listed. Recent carcass recoveries of NOR and hatchery-marked spawn outs in Umbrella Creek have provided new information on the viability of reintroduced tributary spawning aggregations.

The Makah Tribe's sockeye supplementation program has been successful in seeding Umbrella Creek, leading to the re-establishment of significant natural spawning levels in that tributary. Peak adult sockeye observations in Umbrella Creek in 1995 were 19 fish per mile. Peak counts in 1999 were 138 adults per mile (Table 7; Section 2.2.3). Of the 138 spawners per mile observed in Umbrella Creek in 1999, it was estimated that 38% (52/138) were natural origin recruits, yielding an adult replacement rate of 2.7

Although accurate spawning surveys can be conducted in tributary spawning areas, the abundance, productivity, spatial structure, and diversity of beach spawning aggregations of sockeye are poorly inderstood. Scuba, snorkel, and boat surveys of known beach spawning areas in Lake Ozette have been unsuccessful in accounting for the number of adult sockeye enumerated by camera when they entered the lake in 1999, suggesting the existence of other, yet to be identified, beach spawning areas; or high pre-spawning mortality rates during the five - to six - month lake holding period.

A current, collaborative research project has been initiated between MFM and NMFS in 2000 and 2001 to learn more about the spatial distribution and abundance of lake spawners using combined methods of radiotelemetry, sonic/acoustic tagging, and hydroacoustic surveys to track, observe, and enumerate adults before and during spawning (Attachment 1). The 2000 initial pilot study is underway. Combined sonic/radio tags were successfully implanted into 29 adult sockeye during June 2000 (MFM *work in progress*). For return year 2001, plans are underway to sonically tag a statistically representative portion of the return. In this 2001 study, more comprehensive hydroacoustic surveys are also planned to more comprehensively quantify overall adult abundance in the lake before and during spawning. This study should help further determine the viability and status of beach spawning aggregations. In addition to future research of the relationship between limiting factors and the four performance parameters of the natural lake spawning aggregations to assess their status, the potential future plan of only using lake spawning aggregations to supplement themselves, or to bolster production on other lake beaches, will only improve viability of the lake population.

5.2.2) Annual size:
Include past brood stock sizes as well as proposed future sizes. Specify number of each sex, or total number and sex ratio, if known. For natural population brood stocks, explain how their use will affect their population status relative to critical and viable thresholds.

The past numbers of brood stock collected of each sex and sex ratios of brood stock were shown in Table 3 and discussed in detail in Sections 1.9 and 1.10. Numbers of tributary spawners proposed for brood stock collection, beginning in 2000, were discussed at the beginning of Section 5, in Section 9 under Current Release Strategies, and in Section 9.6. A total of 40 pairs is proposed for supplementation in Umbrella Creek and 60 pairs for reintroduction to Big River in 2001. Also, up to five adults from Olsen's and Allen's Beaches are proposed for collection in the next few years to conduct small, replicated experiments on limiting factors during incubation in the lake as described in the beginning of Section 5. The relationship of past brood stock collections to critical and viable thresholds was discussed in the preceding Section 5.1.

Pending investigations that are expected to help us understand the relationship between the four performance parameters (including genetic diversity of the lake spawning aggregations), and limiting factors during spawning and egg incubation, the need for future lake supplementation or reintroduction will be evaluated. Weir counts, spawner surveys in the tributaries and lake, and observations of adult survival from lake entry to spawning in sonic tracking and hydroacoustic experiments, and subsequent evaluations of their productivity, spatial distribution, and diversity; will enable realistic brood stock collection goals consistent with maintaining viable spawning aggregations. In addition to the weir counts, spawner surveys and adult tracking and enumeration methods described above, future collections of lake spawners may employ an abundance-based strategy using conservative catch and recapture limits to avoid overharvesting spawning aggregations (Appendix D). Numbers of beach spawners that may be collected will be determined in the future; however, they will be conservative, abundance-based, dependent on the purpose of the action, and they will be monitored closely to ensure that their resulting progeny benefit from the actions by returning to their intended release sites. Past and proposed sex ratios in brood stock are 1:1.

5.2.3) Past and proposed level of natural fish in brood stock:
If using an existing hatchery stock, include specific information on how many natural fish were incorporated into the brood stock annually.

Natural, lakeshore-spawning, wild stock were the only source of brood stock for the supplementation program from 1983 to 2000. Future numbers of NOR and hatchery origin returns to Umbrella Creek to collect for brood stock for supplementation in Umbrella Creek, or for reintroduction to Big River, were previously described at the beginning of Section 5. Numbers proposed for 2001 were described in Sections 9 and 9.6. From 2000 through 2003, we propose to remove any adult sockeye that can be captured from Crooked Creek before they spawn, if feasible, and also use them for brood stock for tributary plants in replacement of spawners removed from Umbrella Creek (because reintroduction to this stream has been discontinued and because removing these fish before spawning will reduce the potential for hybridization with kokanee). Additionally, this will foster more rapid colonization of natural spawners in Umbrella Creek by reducing removals of natural spawners. Future brood stock collections in the lake, if deemed necessary, will utilize only natural beach spawners at agreed numbers or percentages that are based on methods described in the preceding section, for the sole purpose of bolstering lake spawning aggregations, as previously described.

5.2.4) Genetic or ecological differences:
Describe any known genotypic, phenotypic, or behavioral differences between proposed hatchery stocks and natural stocks in the target area.

There are no known genotypic or phenotypic differences between artificially - and naturally - spawned aggregations at this time. Both originated from wild beach spawners. Also, as previously described, the genetic composition and ecological traits of the extirpated tributary populations is unknown. Reintroduced tributary spawners currently enter their spawning grounds and spawn at the same time as the majority of lake spawning adult sockeye from November through early-January annually. Tributary sockeye fry emergence and outmigration in Umbrella Creek in 1999 occurred from early-April to early-June, with the peak occurring from mid-April to mid-May. Fry emergence in the lake has not been monitored. Emergence in the lake is believed to occur in the same general time frame as for the tributaries because lake and tributary adult spawning times overlap for several months, with lake spawning (warmer incubation temperatures) occurring during and up to several months after tributary spawning (cooler incubation temperatures).

Tributary incubation temperatures are colder than lake temperatures, differing by an average of approximately 2°C**.** This issue was discussed at the end of Section 3, and in Sections 8.4, 9, 9.2, and 9.9. It is important to remember that reintroducing sockeye to Umbrella Creek and Big River poses uniquely different considerations due to the intention to reestablish spawning aggregations in tributaries which are then subject to their new, introduced environments. As previously mentioned, shifting to tributary-origin brood stock is expected to foster local adaptation and accelerate the reintroduction process. These changes from lake stock are expected and desired in new reintroduced spawning aggregations as they adapt to the tributary environments. Emergence timing is expected to be similar to the emergence timing currently observed in NOR, tributary-origin, sockeye and coho fry, which appear to exhibit high rates of reproductive success in certain stream segments of Umbrella Creek, Big River, and their tributaries. Both tributary - and lake - origin sockeye share a common food source in Lake Ozette, which is not believed to be a limiting factor to sockeye production (Beauchamp *et al.* 1995).

5.2.5) Reasons for choosing:
Describe any special traits or characteristics for which brood stock was selected.

Future brood stock acquisition for tributary plants will target adult Lake Ozette sockeye returning to Umbrella and Crooked Creeks. Umbrella Creek returns appear to be rapidly adapting to the tributary environment and returning in greater numbers each year. They appear to be using suitable spawning habitats, and have produced substantive natural origin recruits. Use of this adapted spawning aggregation for future tributary plants should speed recovery and reduce take of the beach spawning aggregations. This was previously discussed at the end of the Introduction Section.

In the past, lake brood stock were chosen to represent the widest possible cross-section of the remnant native stock. Historically, Lake Ozette sockeye salmon brood stock were taken directly from wild lakeshore spawners. Ozette-origin hatchery fish have historically survived and returned in significant numbers to spawn in the Ozette watershed, while Quinault and Baker Lake stocks and kokanee hybrids appear to have not been successfully introduced. This supports the theory that the remnant native stock has genetic adaptations, which increase fitness in the unique environment of Lake Ozette. Furthermore, it indicates that hatchery-origin fish conserve these traits as part of the ESU because they are genetically identical to the remnant native population. Brood stock from the two beach- spawning aggregations have been spawned separately every year except in 1991. In 1991, the two spawning aggregations were not crossed intentionally but no effort was made to segregate them.

5.3) Unknowns:
Identify areas where a lack of data leads to uncertainties about the choice of brood stock.

The primary unknown is the level of genetic differentiation between different beach spawning aggregations on Allen's and Olsen's Beaches and how this will affect potential future lake reintroduction efforts to other beaches with suitable spawning and incubation habitats. Sockeye salmon currently spawn on Olsen's Beach and Allen's Bay Beach and may potentially spawn on other undocumented beaches. The two known aggregations are currently treated as separate populations, but scientific support for this is inconclusive. The National Marine Fisheries Service noted significant differences in allozyme frequencies between spawners from the two locations, which might suggest different populations (Gustafson *et al*. 1997). Significant differences between samples from the same location in different years, however, also suggested that presumed geographical differences were actually reflective of the degree of genetic variation within this ESU. This unknown is being addressed in the genetic study described in Section 12 Attachment 2.

SECTION 6. BROOD STOCK COLLECTION
Describe any inconsistencies with standards and guidelines provided in any ESU-wide hatchery plan approved by the co-managers and NMFS.

This hatchery plan is the only hatchery plan for this ESU and is part of the ESU-wide Lake Ozette Sockeye Recovery Plan and Tribal Resource Management Plan under development.

6.1) Prioritized goals:
List in order of priority the general goals for brood stock collection.
Refer to sections 1.5 and 1.6.

Sufficient brood stock will be collected from tributary returns to attain the goal of fully seeding Big River and Umbrella Creek to re-establish naturally spawning sockeye populations at self-sustaining levels that increase abundance, productivity, distribution, and diversity of the ESU.

Every effort will be made to reduce the chance of both stochastic and deterministic genetic differentiation of hatchery fish from any donor spawning aggregations. This will include such efforts as sampling throughout the timing of the runs and representative size selection. Brood stock collections will be scaled to an appropriate size for annual fluctuations in run size.

Based upon these guidelines, the brood stock used for any future lake plants must be representative, both genetically and ecologically, of the remnant native stock. Because the present remnant lake spawning aggregation may be comprised of two or more subpopulations, the adults from the two known spawning beaches will not be hybridized. In 1999/2000, adult sockeye on Allen's Beach were not captured for supplementation nor for any sampling. A total of only eight carcasses were sampled for genetic analysis on Allen's Beach in 1999/2000 and most of these samples were in very poor, decomposed condition. A total of 27 adults were collected from Olsen's Beach in 1999 to evaluate egg incubator survival in small, replicated studies on Olsen's Beach and in Big River in the winter of 2000 (see Section 4.5 for description of procedure). All eggs planted for tributary and lake studies were uniquely otolith marked. Adult sockeye returning to Umbrella and Crooked Creeks (2000 through 2003 only) will be used exclusively as brood stock for releases into Big River and Umbrella Creek beginning in 2000.

6.2) Supporting information:

Brood stock collection will be conducted in accordance with NMFS standards and guidelines for artificial propagation under the ESA (Hard *et al*. 1992) and by the guidelines for Integrated Recovery plans in the Comprehensive Coho and Chinook Management Plans, as previously described in Section 2.1.

6.2.1) Proposed number of each sex.

Tributary Program: Numbers of tributary returning brood stock to collect for reintroduction to Big River and for supplementation of the Umbrella Creek run, beginning in 2000, were previously discussed at the beginning of Section 5, and are discussed in Sections 9 and 9.6. Numbers of beach spawners collected in the past for tributary reinroduction were previously shown in Section 1.9 (Table 3).

Future Beach Program: Small numbers of beach spawners proposed for collection in the near future for the purposes of conducting research experiments on limiting factors during egg incubation in the lake were also discussed at the beginning of Section 5. Proposed future methods to determine available numbers of beach spawners for collection for supplementation or reintroduction of the beach spawning aggregations were discussed in Section 5.2.2. and in Appendix D.

Actual numbers of beach spawners collected in the past averaged 99 adults ± 20, ranging from 0 to 205 adults (the average take was less than 50 pairs). Egg takes over the past 14 years have ranged from 0 to 315,746 eggs with an average and SEM of 106,989 ± 26,328 (Figure 24). All eggs collected from beach spawners in the future, if deemed appropriate, will be returned to the lake. This will remove lake-origin brood stock mining concerns for tributary plants. Survival is expected to increase through hatchery methods and abundance, productivity, spatial distribution, and diversity are also expected to increase by reintroducing healthy, eyed eggs to more productive habitats. Mitigation plants will be conducted to, at a minimum, replace any eggs collected and will be representative of all individuals collected.

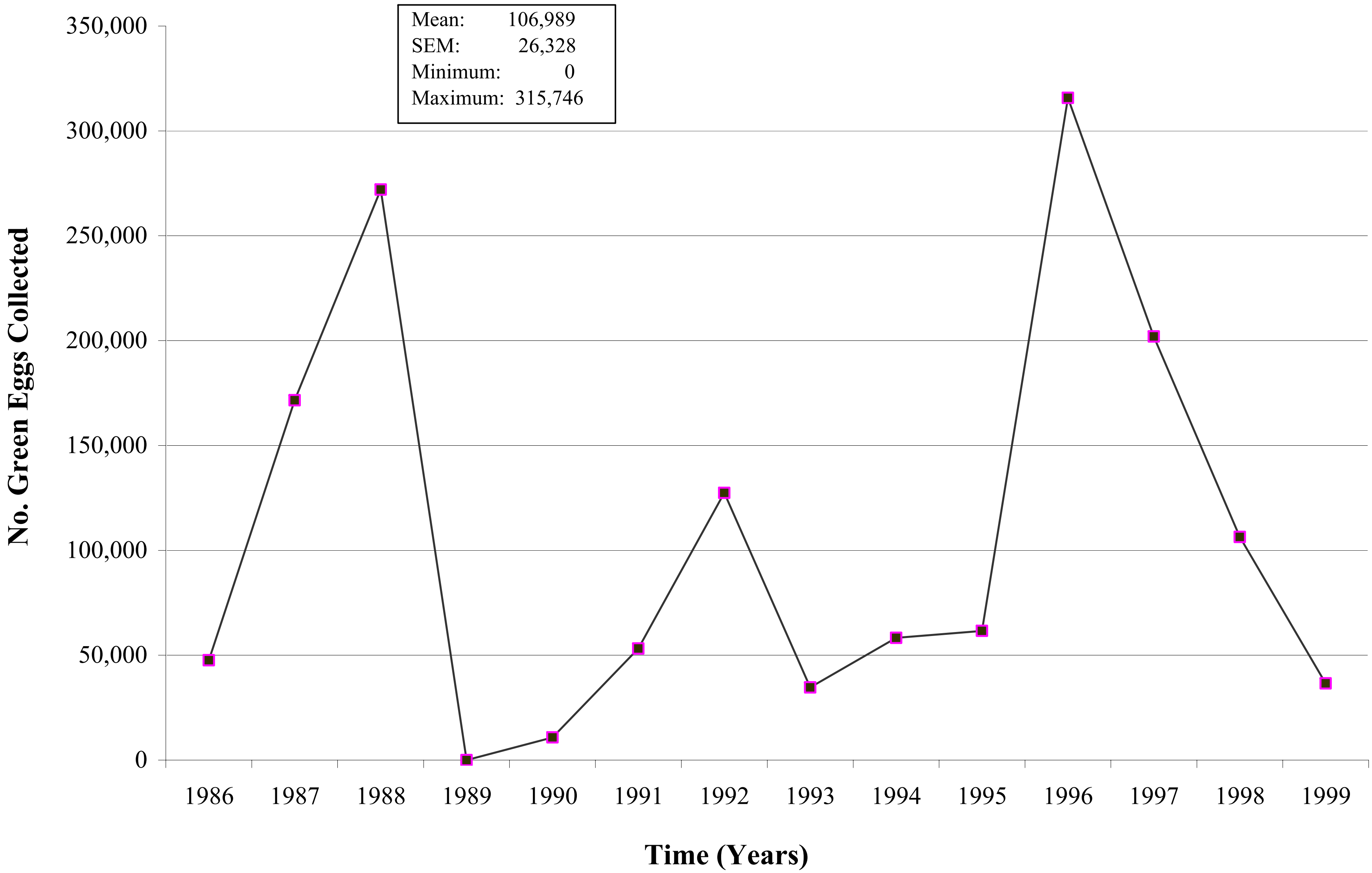

Figure 24. Green Eggs Collected From Lake Ozette sockeye at Umbrella Creek Hatchery.

In 1998 for example, only 87 adults were collected from Olsen's Beach (about 6.2% of the run; without using the current conservative catch and recapture limits). The eyed egg mitigation plant back to the source beach was 25% of the original green egg take (more than were projected to have survived without any brood stock collection). Egg takes have been reduced or eliminated in past years on low return years such as in 1989. In the fall of 1999, we intended to capture 33 pairs (3.2% of the total run size or 3.5% of the estimated spawning population using a preliminary lake escapement estimate past the weir in the summer of 1999 of 2,076 adults and a 90% survival rate to spawning). Although the collection goal for 1999 was 33 pairs (66 fish), the actual collection was only 28 fish (1.3% of the total run size), using conservative catch and recapture limits. Eggs collected from these fish were used to measure survival and demonstrate the effectiveness of incubator plants in the lake and in Big River.

6.2.2) Life-history stage to be collected (e.g., eggs, adults, etc.):

Partially ripe and ripe adult sockeye will be collected primarily from a trap near the mouth of Umbrella Creek in 2000. Green or partially ripe adult Lake Ozette sockeye were captured from Olsen's Beach in the fall and winter of 1999 for genetic analysis and spawning, but no adult spawners were captured from Allen's Beach in 1999. No adult spawners have been collected for brood stock from Allen's Beach since 1996. In 1998, non-lethal fin tissue samples were collected for genetic analysis from 24 spawn outs captured in late-December on Allen's Beach. Beginning in fall-winter 2000, three to five partially ripe adult sockeye will be captured from each of the two currently known spawning beaches for research on limiting factors at their source beach and to address limiting factors related to future reintroductions to other appropriate lakeshore habitats. Also beginning in the fall of 2000, 50 to 100 fin tissue samples will be collected from carcasses on Olsen's Beach and on Allen's Beach. Some fin samples may be collected non-lethally from live adults, if necessary, targeting spawn outs to achieve adequate sample size to discriminate differences.

6.2.3) Collection or sampling design:

Include information on the location, time, and method of capture. Describe capture efficiency and measures to reduce sources of bias that could lead to a non-representative sample of the desired brood stock source. Also, describe the method of capture (e.g. weir trap, beach seine, etc.) and quantify as take handling, behavior modification, stress, or mortality of listed fish.

In consideration of recent direction from NMFS, tributary brood stock will replace lake stock for all future tributary releases beginning in 2000. They will be easily collected in appropriate numbers by trapping complemented by seining in lower portions of Umbrella Creek. Most fish will be trapped but some will be captured using tangle gill nets as previously used in lake capture as described in Section 6.2.3, or with one inch mesh seines, and transported by truck under oxygen to the Umbrella Creek Hatchery. Umbrella and Crooked Creek spawners may alternately be spawned at their capture sites and their gametes and tissues transported in labeled bags under oxygen to the isoincubation facility for fertilization, disinfection, and water-hardening. Tributary spawning aggregations will be used as the source of brood stock for tributary releases beginning in 2000, as previously described in Section 5. Other locations for collections on the spawning grounds will be based upon in depth examinations of channel-specific, habitat and density-dependent spawner analyses in tributaries such as the number of spawners per mile, the amount of redd overspawning/redd superimposition, or the relative survival and productivity measured among and within specific stream segments. Tributary brood stock will be utilized only for tributary plants.

For collection of brood stock for tributary reintroduction and supplementation beginning in the fall of 2000, we propose to place a removable weir trap near to the mouth of Umbrella Creek starting when adult sockeye begin staging at the river mouth in October annually. Trapping operations will continue intermittently through December each year, in response to the adult upstream migration and weather/flow variations. This full-spanding weir and trap will be monitored when in operation. Panels will allow juvenile passage and will be removable if necessary to allow other delayed fish to pass the structure. Adults captured in the trap will be removed at least once daily, corresponding to guidelines and agreed to percentages or numbers of brood fish to collect from the return to Umbrella Creek (see Section 5 above). This number of brood stock will be taken temporally in measured proportion to the return to the stream. This will be accomplished by enumerating all returns daily and collecting the agreed percentage of each sex (1:1 sex ratio for brood stock).

A total of 100 pairs are proposed for year-2000 takes in Umbrella and Crooked Creeks combined (see Sections 9 and 9.6). The timing of brood stock collection (beginning to end of river spawning period) and proportional capture of adults returning to their spawning areas relative to their abundance will ensure that a representative portion of the entire run is collected. Sex ratios will be recorded. Trapping mortality is expected to be very low. The adult Lake Ozette sockeye will then be transported in fish tanks by truck under oxygen for approximately 20 minutes to the Umbrella Creek Hatchery for holding, spawning and genetic sampling.

We also propose a concurrent strategy to seine partially ripe and ripe sockeye between RM 1 and RM 4 in Umbrella Creek and from Crooked Creek (return years 2000-2003 only) during this same period if necessary. Agreed percentages or numbers of green and partially ripe adults will be collected throughout the run, as previously described, and numbers of each sex and clipping and tagging rates recorded. Adults not ready to spawn will be held temporarily in live boxes in the Creek, transported to the Umbrella Creek Hatchery in a hauling truck as previously described, and held until ripe in flow through tanks. Gametes of ripe fish will be collected at the river and labeled. Milt will be placed into oxygenated plastic (Whirl Pac) bags and eggs will be placed in plastic containers. Both will be transported above ice (insulated) to the isoincubation facility for random matrix fertilization and disinfection Carcasses from ripe fish spawned riverside will be returned to their stream of origin after gametes are removed. Gametes will be transported to the isoincubation quarantine facility for random matrix fertilization and disinfection.

For experimental lake collections in the near future, approximately three to five adults will be captured and spawned to provide eggs for studies on limiting factors during egg incubation at spawning beaches of origin or to study limiting factors related to reintroduction to appropriate lakeshore habitats. Also in 2000 and 2001, 50 to 100 fin samples will be collected for genetic analysis from carcasses or from live adults, targeting spawn outs from each beach. The live adults will be carefully released upon non-lethally excising the fin clips and noting presence/absence of adipose clips (Section 12; Attachment 2).

All adults captured from both beaches for non-lethal genetic sampling in late-December through mid-January in 1998 were already spawned out (MFM unpublished data). In 1999, brood stock were collected from Olsen's Beach on four occasions between 11/29/99 and 12/23/99. On the first collection, less than one third of the adults were green (18/58; 31%) whereas most adults were already ripe (20/58; 34.5%) or spawned out (20/58; 34.5%). By 12/23/99, no green fish could be captured and only two ripe fish could be found on Olsen's Beach. Also on 12/23/99, attempts were initiated to capture post-spawning adults for genetic sampling on Allen's and Olsen's Beaches, but no other sockeye were captured or seen by either the scuba surveyors or the hatchery crew. Additional capture attempts occurred on January 4, 12, 21, and 27, and February 4, 10, and 15, 2000, often in conjunction with scuba surveys for redds and spawners, to obtain non-lethal fin clips for genetic analysis and to learn more about any late-spawning component on both Allen's and Olsen's Beaches in winter of 2000. No adult sockeye were captured or seen on any of these attempts nor were any seen by the survey crews except for a single green female that was captured on 2/4/00 on Allen's Beach. A few new redds were observed during scuba surveys on Olsen's Beach as late as 1/21/00 and one new redd was observed on 12/22/99 on Allen's Beach (ONP and MFM unpublished data).

Potential future lake-origin brood stock capture methods need to be refined to ensure that spawning aggregations are never over-harvested. Preliminary methods are described in Appendix D for the purposes of initiating these discussions and to describe the method that was employed in 1999.

As previously stated, only lake stock would be used for any future lake supplementation and lake beach reintroduction projects, the scale of any future lake brood stock takes would be small and abundance-based, and sufficient numbers of eggs will be otolith marked to allow for accurate monitoring and evaluation upon release.

An initial request for otolith funding (second part of Attachment 2) to the HSRG in 2000 was not accepted and a new proposal using different and traditional otolith analysis methods is currently being submitted for funding. In spite of this lack of funding, the Tribe paid more than $10,000 in brood years 1998 and 1999 to collect samples, have otoliths read, and to provide equipment for otolith marking, such as generators, electrical wiring, chillers or heaters, and other equipment. Future hatchery reform monies are supposed to become available for this desperately needed monitoring. Support from NMFS to the HSRG to fund Lake Ozette sockeye otolith monitoring work in the future is needed and greatly appreciated.

Meanwhile, the Tribe will do as is necessary to mark sufficient numbers of eggs to allow for accurate monitoring and evaluation upon release. Sufficient numbers of fry and fingerlings that are released beyond the swim up phase will be otolith marked and fin-clipped. Decisions on which release strategies to employ will be made based on the relative post-release survival and reproductive success of differentially-marked release groups. If monitoring and evaluation prove that the program is failing, the program will be revised or aspects of the program will be terminated as necessary.

6.2.4) Identity:
Describe method for identifying (a) target population if more than one population may be present; and (b) hatchery origin fish from naturally spawned fish.

Tributary spawning aggregations will be identified upon return to their respective streams. Future identification of each beach spawning aggregation will be differentiated by their spawning location on eastern or western lakeshores. Separate collection efforts will be undertaken for all spawning aggregations, and they will remain segregated throughout the duration of their hatchery experience. Since collection efforts target adults from their respective spawning grounds, separation of unique genetic stocks will be maintained. Both beaches are no touch zones for brood collection for supplementation in the near future (collections will be limited to a few fish from each beach for research purposes). Sufficient numbers of supplementation fish will be otolith-marked and the otoliths from sufficient numbers of spawners will be analyzed. Sufficient numbers of fish released as fingerlings will be fin clipped. In addition to otolith mark reading of spawners, the incidence of adipose clips in the total run will be recorded and analyzed on video tapes as well as in all spawners and carcasses collected. Numbers of NOR and hatchery fish collected for brood stock for tributary releases will be representative to the proportions of NOR and hatchery origin fish observed in the returns to Umbrella Creek (Section 5).

6.2.5) Holding:
Describe procedures for holding fish, especially if captured unripe or as juveniles. Quantify as take trapping, holding, stress or mortality of listed fish.

Following capture, green sockeye from a single spawning location will be transferred to the Makah Tribe's Umbrella Creek Hatchery and held in covered circular holding tanks, segregated by origin of capture, until sexually mature. Pre-spawning mortality shown in Section 10.3.2 (Table 18) at the holding facility has improved since adult transfers were first initiated. Most holding mortality occurred in 1991 (net pen holding) and in 1988 (cage holding) when attempts were made to hold adults in the lake until mature. These methods were discontinued. Since 1991, holding mortality has been primarily due to a lack of monitoring when inadequate personnel were available to monitor adult holding during a freshet which caused a temporary water failure (1997) and when tank lids were left uncovered (1995). Tank lids remain on and additional FTE's have been hired and assigned to monitor all fish held at the Umbrella Creek facility. Due to increased monitoring at Umbrella Creek, combined with effective capture techniques, we expect the capture to spawning mortality rate to be less than 6%. Total capture and holding mortality in 1998 and in 1999 was 3.4% each year.

6.2.6) Disposition of carcasses:
Include information for spawned and unspawned carcasses, sale or other disposal methods, and use for stream reseeding.

Carcasses resulting from spawners removed from Umbrella Creek will be returned to the stream after spawning and removal of the tail to distinguish brood stock from river spawners during surveys. Carcasses resulting from spawners removed from Lake Ozette will be returned to their beach of origin after spawning and removal of the tail to distinguish brood stock from other carcasses during surveys.

6.3) Unknowns:
Identify any data gaps that lead to uncertainties about brood stock collection.

Monitoring genetic composition of brood stock and carcasses and spawn outs from lake beaches will continue to help determine whether the genetic differences between the two beach spawning aggregations are significantly greater than the between year class genetic differences. The Makah Tribe and NWIFC the recently submitted a recent joint preproposal to conduct this work.

It will be important to determine the existing genetic differences between years of Ozette sockeye within each of the spawning aggregations and to compare those differences to those measured between the spawning aggregations. We must know how these determinations will affect genetic and ecological concerns, and future hatchery operation plans. However, until this relationship is determined, we will assume that the two spawning aggregations are distinct.

When collecting tissue samples from live fish for genetic analyses, non-lethal fin clip samples collected from each fish will be placed into test tubes containing 100% ethyl alcohol. In 1998 and 1999, MFM collected 165 and 127 tissue samples, respectively, from beach spawners as part of the ongoing effort to collect these data for future comparisons.

In 1999, duplicate tissue samples (fin, eye, heart, liver, and muscle) were collected from each of 28 brood stock captured from Olsen's Beach. An additional 91 fin tissue samples were also collected non-lethally from adult sockeye captured, but not retained for brood stock, from Olsen's Beach in 1999. Also in 1999, eight fin tissue samples were collected from carcasses on Allen's Beach, 56 fin clips were collected from adult carcasses and snagged spawn outs in Umbrella Creek, and 145 whole NOR sockeye fry were retained from fyke netting in Umbrella Creek. All of the 1999 tissue samples were frozen in an ultra-cold freezer to enable allozyme and DNA testing (most samples were collected in duplicate).

If the two spawning aggregations are not determined to be genetically distinct, we may be unnecessarily restricting what may be a beneficial gene flow between the two spawning aggregations. Further genetic analyses, examination of incubation temperatures of springs and ambient lake temperatures, and careful measurement of spawning times of the two beach spawning aggregations is continuing. Makah Fisheries Management began conducting these measurements and has refined procedures for acquiring accurate, useful information in the future.

Marking procedures for monitoring the abundance and distribution of hatchery-origin spawners as well as a determination of their role in the supplementation process has been developed. We estimate that approximately 85% of the overall run can be analyzed for the incidence of fin clips by the underwater video camera. Beginning with the 2000 return, the adipose clip incidence of all viewable adult sockeye images observed by tape reviewers will be recorded. Significant numbers of spawn outs and carcasses will be examined for fin clips and otolith marks in Umbrella Creek and on the lake beaches annually. All brood stock will be examined for both types of marks unless it is determined that a subsample will suffice to accurately determine the proportion of these stock components in the brood. Numbers of natural - and hatchery - origin adults can be determined within tributary and lake spawning aggregations.

SECTION 7. MATING

Use standards and guidelines provided in any ESU-wide hatchery plan, or other regionally accepted protocols (e.g. IHOT) approved by the co-managers and NMFS. Explain and justify any deviations.

Mating procedures will be conducted in accordance with NMFS guidelines for artificial propagation under the ESA (Hard *et al.* 1992). A partial factorial mating procedure using a 4 X 4 spawning matrix will be followed. Although this is not true random mating, the adults spawned in each factorial mating will be randomely selected from the pool of eligible ripe adults on each spawning date. This factorial design was chosen to minimize the effects of selection because it lowers the risk of reducing the effective population size, it increases the probability of unique genetic combinations in the brood, and it provides for backup fertilization.

As detailed in the NOAA Technical Memorandum NMFS-NWFSC-2 (Hard *et al.* 1992), random matings maximize effective population size and minimize artificial selection pressures. As previously described, a 4 X 4 spawning matrix would result in an effective population size of approximately 168. The minimum effective population size has been estimated to be 80 -100 spawners for short term projects (Hard *et al.* 1992; Ken Currens personal communication). Based on these guidelines, we recommend adopting the 4 X 4 matrix spawning design. We have already adopted this matrix for all of our hatchery programs because it readily accommodates our present incubator capacity, promises to maximize the genetic variability of our stocks, and doesn't add appreciably to spawning logistics due to the relatively low number of spawners processed. Control of vertical transmission and cross contamination is accomplished by water hardening, rinsing, disinfecting in 100 ppm iodophor (Section 7.3), isoincubating each matrix-spawned egg lot, and using general sterile technique during adult holding, gamete collection, and fertilization.

7.1) Selection method:

Specify how spawners are chosen, e.g. randomly over whole run, randomly from ripe fish on a certain day, selectively chosen, prioritized based on hatchery or natural origin, etc.

Tributary spawners, captured throughout the run into Umbrella Creek, will be randomly selected over the entire run from green and ripe, wild and hatchery adults representative of the overall Umbrella Creek spawning aggregation (Section 5). Hatchery and wild brood stock will be collected in proportions relative to those in the overall return to Umbrella Creek (Section 5). If any fish are collected from Crooked Creek, they will be used in the same proportion as in the return.

The remnant wild lake population is known to utilize two spawning beaches within Lake Ozette: Olsen's Beach and Allen's Bay Beach. These beaches are located on opposite sides of the southern third of the lake. Olsen's Beach, adjacent to low hills on the east bank, is a compact spawning beach with a routinely higher concentration of spawners than have been recently observed at Allens Beach. Although adult spawners have been observed as early as the beginning of November (MFM unpublished data), and as late as the third week of January (Dlugokenski *et al*. 1981) annually, spawning was observed to have been completed by mid-December on Olsen's Beach in recent years (1998 and 1999; MFM unpublished data) . Because of the consistently larger natural spawning component at this site, which is currently considered the primary spawning beach, this beach has been the primary source of brood stock for this recovery program prior to return year 2000.

Allen's Bay Beach is a larger, more exposed spawning area, with it's contour sloping rapidly into deeper water and a correspondingly lower concentration of spawning activity. Although the viewing conditions at this site are often poor due to the rapid rate of exposure, depth, and typically severe weather conditions during November each fall, spawning is generally not observed at the Allen's Bay Beach until one or two weeks later in mid-to late-November, although a few early spawners were observed in November when spawning had just began at Olsen's Beach in 1999 (MFM unpublished data). Despite many attempts to locate late spawners on any of the beaches after January in the 1998/1999 and 1999/2000 spawning seasons, only one adult sockeye was found on Allen's Beach in 2000 (MFM unpublished data). Dlugokenski *et al*. (1981) reported relatively large numbers of spawners on Allen's Beach in January with significant numbers spawning into February of 1979. However, peak spawning on Allen's Beach, like Olsen's Beach, has been completed by December in recent years, with very low numbers of adults observed (MFM unpublished data). Spawn timing for both beaches continues to be more accurately measured and compared.

The brood stock collection effort will occur throughout the natural spawning period observed on spawning grounds of the given donor spawning aggregation. As previously mentioned, agreed proportions of fish to collect will be representatively selected over the entire spawning period. Brood stock held at the hatchery will be sampled weekly or bi-weekly to determine ripeness. All ripe individuals encountered on any spawn date will be assigned random numbers, then randomly selected and mated with individuals from the same spawning aggregation.

Presuming that lake beach supplementation and/or reintroduction is proposed in the future, the benefits of reintroduction and supplementation, such as increasing abundance, productivity, spatial distribution, and diversity of the ESU, and addressing limiting factors; must continue to be evaluated against the risk of doing nothing or against risks associated with genetic and ecological challenges related to supplementation of the donor spawning aggregation or with collection of eggs for reintroduction to new lake beach sites.

7.2) Males:
Specify expected use of backup males and repeat spawners.

We will not specifically use a backup male spawning strategy in the normal sense of the definition. However, our mating protocol (see below) will effectively provide backup fertilization for each female. Partial spawners and spent adults will be released upon capture. However, because their prior spawning activity is often difficult to ascertain, it is conceivable that males that have spawned naturally will also contribute to the hatchery gene pool.

7.3) Fertilization:
Describe fertilization scheme, such as equal sex ratios and 1:1 individual matings; equal sex ratios and pooled gametes; or some other. Explain any fish health procedures used for disease prevention.

To maximize genetic variability within hatchery spawning aggregations, we will conduct 4 x 4 matrix spawning as previously described. The benefits of this protocol include: normalizing the contribution of each adult used for brood stock, maximizing the genetic variability, and reducing the logistical difficulties associated with a complete matrix design (every female mated with every male). Employing this scenario, eggs and sperm from each spawner will be collected in labeled plastic containers or bags, respectively, and transported under oxygen (sperm only) in a cooler insulted above ice to the Educket isoincubation quarantine building in brood years 1999/2000 and 2000/2001, and to the MNFH isoincubation building beginning in 2001/2002, for fertilization. The external and internal surfaces of the cooler will be disinfected prior to transfer. At the quarantine building, the eggs from each female will be divided into four equal aliquots. Each of these aliquots will be fertilized with a different male. After allowing sufficient time for fertilization, but prior to a decrease in sperm motility, the four aliquots will be recombined thereby effectively providing backup fertilization. Each of the males will fertilize one fourth of the eggs from each of four females to provide an overall male to female spawner ratio of 1:1. Daily spawning, egg fertilization, and antifungal treatments during incubation follow:

A. Adults, segregated by origin, will be sorted for ripeness.
B. Tissue samples will be taken from 100% of the spawners and processed by a NWIFC pathologist

according to infectious fish pathogen detection protocols established by the Washington State Fisheries Co-Managers Salmonid Disease Control Policy. This currently requires viral and bacterial assays of coelomic fluid, kidney/spleen, and milt tissues excised from four-fish-pools.

C. Eggs will be fertilized using a 4 X 4 spawning matrix.

D. Fertilized eggs will then be rinsed and water-hardened in 100 ppm iodophor.

E. Eggs will receive a prophylactic formalin treatment on alternate days to prevent saprolegnia fungus.

Embryo development will be monitored throughout the incubation period and temperature data, hatching, and emergence times will be projected after eggs reach the eyed stage. All eggs will receive differential mass thermal otolith marks as per methods coordinated with the WDFW Otolith Laboratory to facilitate future identification of fish used for supplementation as part of the monitoring program. Eyed egg aliquots, representing each gene pool, will be set aside for eyed egg transfers. Eyed egg aliquots, representing each gene pool, will also be partitioned for fry and fingerling releases and transferred to bulk (Nopad style) incubators containing rugose substrate for subsequent hatching and swim-up at the Umbrella Creek Hatchery.

Sex ratios in Umbrella Creek have not been determined but the sex of all adults captured in future trapping and netting efforts will be recorded. Sex ratios of all fish captured in the lake were not recorded in years prior to 1999 (the hatchery crew only recorded sex of fish retained for spawning but not of fish released after capture). The sex of all fish captured was recorded in the 1999/2000 brood collection and genetic sampling season. Of a total of 121 adults captured from Olsen's Beach, 75 (62%) were males and 46 (38%) were females. However, brood stock were spawned at a ratio of 1:1 as previously described. As previously mentioned, the anticipated spawning ratio in Umbrella Creek brood stock will also be 1:1 using the 4 X 4 spawning matrix previously described. A total of 28 brood stock were retained for spawning in 1999 from Olsen's Beach, one died during holding leaving 15 males and 12 females used in the matrix spawning previously described.

The average fecundity for this stock is approximately 3,050 eggs as determined by Makah Fisheries Management (Section 10.3.1; Table 17).

This stock, as determined by scale analysis, is predominantly comprised of four-year-old individuals; however, a small number of three year olds have been observed passing by the weir and have been observed on the spawning grounds in low numbers (MFM unpublished data). Dlugokenski *et al*. (1981) identified only a few three-year-old fish between 1977-1979. The most recent scale analyses conducted by WDFW on 1998 brood stock revealed that 71/71 (100%) were 4_2. Another recent scale analysis conducted in conjunction with a 1994 GSI study identified 80 of 80 samples as four-year-olds. The relative proportion of three-year-old adult returns of the total run size in any given year appears to be influenced by the run size on the following year. If the subsequent run size is large, as the 2000 return was to the 1999 return, then more three-year-olds would be expected in the previous years' return.

7.4) Cryopreserved gametes:

If used, describe number of donors, year of collection, number of times donors were used in the past, and expected and observed fertility.

No cryopreservation component is anticipated for this program.

7.5) Unknowns:

Identify any data gaps that lead to uncertainty in mating protocols.

The most essential monitoring for this phase of the recovery effort is the adult fish health certification. This requires tracking individual gametes associated with numbered egg lots for infectious fish pathogens, particularly infectious hematopoietic necrosis virus (IHNV), destined for inter-watershed transport to the isoincubation facility. No infectious pathogens have been detected in Ozette sockeye brood stock taken from lake beaches and spawned at the Umbrella Creek Hatchery over the past six years (through 1999); however, IHNV was detected in 12/12 pooled tissue samples from brood year 1992 spawners. The progeny were eventually destroyed. Iodophor rinsing and disinfection of eggs, combined with isoincubation, will greatly reduce the possibility of vertical or horizontal transmission of IHN virus occurring. Operating protocols have been defined by the disease subpanel in the event of another IHN virus detection, as previously described in Section 4.3 under egg incubation at MNFH and Educket.

SECTION 8. REARING AND INCUBATION

(Note: The information requested in this section is under evaluation to determine if additional standardization is needed to assure relevancy and utility.) Provide current and previous goals and data. Include historic data for three generations or for years dependable data are available. Use standards and guidelines provided in any ESU-wide hatchery plan, or other regionally accepted protocols (e.g. IHOT) approved by the co-managers and NMFS. Explain and justify any deviations.

Rearing procedures will be conducted in accordance with NMFS guidelines for husbandry techniques under the ESA (Hard *et al.* 1992). Primary importance will be placed on minimizing artificial selection in the supplementation process. Accordingly, emphasis will be placed on minimizing mortality in the hatchery environment and releasing the fish as quickly as is prudent to minimize the effect of culture conditions on characteristics such as behavior (foraging, predator evasion, use of natural cover, structure, and substrate), external coloration and spotting, and disease resistance capabilities; and to expedite their return to the natural environment. While it is understood that the natural environment cannot be duplicated in a hatchery, rearing protocols will attempt to minimize the differences. Human contact will be held to the minimum necessary to ensure that fish health remains optimal and rearing systems are adequately monitored. All intended planting strategies (eyed egg plants, unfed and fed fry < 1 gram) occur during the very early stages of sockeye development, reducing the length of exposure of fish to the artificial hatchery environment and resulting domestication effects.

Natural hatching and rearing is proposed in future RSI's on imprinting and release ponds on Big River and/or its tributaries and possibly in the upper portions of the Umbrella Creek watershed, if deemed appropriate to increase colonization of upper portions of the drainage. Recent reconnaissance was conducted by MFM to survey potential sites on the mainstem and tributaries of Big River suitable for constructing an RSI and imprinting pond. A suitable location was found on an unnamed tributary to Big River located upstream from the mouth of Solberg Creek, another tributary to Big River. We propose to set up a small, gravity feed incubation box at this site in 2001 and to develop an imprinting pond in cooperation with the landowner. This hatching and imprinting site will be used to augment or replace eyed egg plants, to allow for hatching, imprinting, volitional emergence from semi-natural incubation habitat, and to provided rearing, feeding (natural and processed), and imprinting in a natural pond/side channel of the river. If natural and/or artificial feeding is desired and feasible, this should also improve postrelease survival by increasing size and development at release.

Throughout the incubation and rearing stages, we will continue to segregate eggs and fish from Umbrella and Crooked Creeks, Allen's and Olsen's Beaches (fish on lake beaches will only be collected for experimental purposes in the near future, but beach supplementation programs may be reinitiated at a later date pending research findings).

EGG INCUBATION:
8.1) Number of eggs taken and survival objective to ponding:

Table 9. A 12-year history of egg collections and survival rates to release.

Brood Year	No. Green Eggs Collected	No. Fry Ponded	Survival to Ponding	No. Progeny Released
86	47,634	41,731	87.61%	12,400
87	171,555	133,351	77.73%	133,300
88	272,037	203,848	74.93%	199,767
90	10,837	10,148	93.64%	9,504
91	53,195	42,143	79.22%	36,703
92	127,378	117,897	92.56%	0
93	34,636	29,682	85.70%	28,171
94	58,287	44,881	77.00%	44,432
95	61,619	46,890	76.10%	45,220
96	315,746	270,287	85.60%	266,295
97	201,958	190,084	94.12%	187,756
98	106,369	70,421	66.20%	69,328

The total number of green eggs collected from 1986 to 1999 was 1,497,851 green eggs. The inter-annual grand mean ± SEM was 106,989 ± 26,328 among collection years, with a range of 0 - 315,746, n = 14 (Figure 24). The overall number ponded from 1986 to 1998 was 1,201,363 fry. The inter-annual grand mean ± SEM was 100,114 ± 23,967 fry ponded among collection years, with a range of 10,148 - 270,287, n = 12. The overall total number of progeny released from 1986 to 1998 was 1,032,876. The inter-annual grand mean ± SEM was 86,073 ± 25,547 progeny released among collection years, with a range of 0 - 266,295, n = 12.

Actual green to eyed, eyed to swim up, and swim up to release survivals over the past 12 years have averaged 83.9%, 98.3%, and 86.0%, respectively. The 13-year average survival rate to ponding from 1986 to 1998 was 82.5%. Our future survival objectives are higher than the average rates because the causes of mortality in the past have been eliminated or greatly reduced. Future survival is expected to not exceed these minimum survival objectives.

No fish were collected in 1989 due to low abundance. No progeny were released in 1992 due to an IHN epizootic. The cause for the low number released in 1986 is thought to be an inventory error and not due to mortality but since the cause could not be determined, the release number of 12,500 is the best available information for that year. The poor survival from green egg to ponding in 1998 was attributed to a sodium bicarbonate rinse prior to iodophor disinfection. This method was proven to be effective in other species of salmon to help remove broken egg shells and organic debris in coelomic fluid which bind iodophor and reduce the desired concentration of disinfectant. The procedure entailed adding 4 pounds of baking soda (1.82 kg) to 35 gallons of water (105 liters; 17.3ppt final concentration) and then rinsing the fertilized eggs. This procedure has been discontinued.

In 1999, the goal was to collect 33 females (100,650 eggs using fecundity of 3,050); however, the actual collection was only 12 females (36,660 green eggs) due to the conservative catch and recapture methods previously described. The collection goals for 2000 and beyond for tributary brood stock were described in Sections 5, 9, and 9.6. Based on annual abundance, the number of brood stock taken will fall within the range described in Section 5. Annual egg take objectives will be determined by applying female ratio to brood stock take and fecundity of 3,050. The survival objective of tributary origin eggs will be the same as for lake origin eggs.

8.2) Loading density:

Include description of the incubator (refer to Section 4.4).

Also, provide measurement of egg size.

Egg loading densities have been very low and are expected to remain low in hatchery facilities. Eggs from single females will be matrix spawned and housed within individual half gallon isoincubators as previously described in Section 4.3 Physical Description of Educket Hatchery in 1999/2000 and in 2000/2001. Eggs from single females will be housed within one gallon isoincubators at MNFH beginning in 2001/2002 as previously described in Section 4. Once eyed eggs are otolith marked at the isoincubation facility, those eggs that are not planted (destined for fry or fingerling plants into Umbrella Creek) will be transferred to the Umbrella Creek Hatchery where pools of no more than approximately 12,000 eyed eggs, from up to four females, will be consolidated, based upon parental pathogen status, and held at low density in Heath trays until just prior to hatching (Section 4.3). Egg diameter has not been measured. Egg size and number has been determined each year using the volumetric displacement method. Egg volume has been very consistent over the past 11 years of measurements with an overall average displacement of 9.38 ± 0.05 eggs/ml or 0.107 cc per egg (Table 10).

Table 10. Egg volume by displacement.

Brood Year	Eggs/ml. of displacement
1987	9.37 ± 0.08
1988	9.43 ± 0.48
1990	8.92 ± 0.00
1991	9.75 ± 0.35
1992	9.40 ± 0.13
1993	9.37 ± 0.06
1994	9.42 ± 0.23
1995	9.37 ± 0.27
1996	9.34 ± 0.09
1997	9.41 ± 0.03
1998	9.36 ± 0.43

Hatching will be accomplished within a Nopad incubator system at the Umbrella Creek Hatchery. These bulk stainless steel incubators are designed to incubate up to 500,000 alevins. Twelve to twenty gallons per minute of inflow water will be supplied along the edges of these incubators. The newly-hatched alevins are allowed to migrate through a vexar screen into the substrate separated from dead eggs which remain on the surface of the top screen thereby facilitating their removal. Once the alevins have reached the buttoned-up stage, they volitionally emigrate up through the substrate and follow the water flow path into a fiberglass starter raceway. A detailed description of the incubators was provided in Section 4.3.

8.3) Influent and effluent gas concentration:

(Dissolved Oxygen, and any other parameters monitored)

Dissolved oxygen is at saturation in our incubation facilities (10 to 11 ppm). See Section 3 for water quality data at MNFH.

8.4) Ponding:

Describe degree of button up, cumulative temperature units, and mean length and weight

(and distribution around the mean) at ponding. State dates of ponding, and whether swim up and ponding are volitional or forced.

Ozette sockeye swim up in varying degrees of incomplete button up after accumulating an average of 1,400 temperature units (Tables 8 and 11). Upon review of nine different spawnings from five different years between 1986 and 1996, the cumulative TU's to hatching was recently adjusted, increasing from 950 to 1000. Temperature tables listing sockeye TU requirements as 900, 1200, and 1800 (Piper *et al*. 1982) for eye up, hatching, and swim up, respectively, are higher than those observed in Ozette sockeye (Table 11). As previously shown near the end of Section 3 (Table 8), when these requirements are used to estimate time differences to accumulate temperature units among lake and tributary incubation temperature regimes, the "delay" in development of tributary fish from lake fish to achieve eye up, hatching, and emergence stages are projected to be 12, 26, and 37 days later, respectively, than eggs spawned at the same time in the lake.

However, NOR sockeye emerging in Umbrella Creek in April 1999 emerged and emigrated at the same time as the productive (50,000 NOR) coho salmon fry emigration from Umbrella Creek into Lake Ozette (Figures 16 and 17). In 1999/2000, it was estimated that NOR sockeye spawners in Umbrella Creek replaced themselves nearly three-fold over the parent brood year (Section 2.2.3). Tributary emergence falls within the emergence window of lake spawning sockeye because lake spawning has been known to occur in the past as late as 2 to 2.5 months later than the time window when tributary spawning is currently observed. Methods to reduce differences in development were also discussed in Section 3 which included eyed egg plants (less than two week delay) and incubation at Educket Hatchery in water with a similar incubation temperature.

Potential advantages of unfed versus fed fry release strategies were discussed in Section 3 below Table 8. Potential factors inhibiting sockeye fry outmigration to the lake such as changes in environmental conditions during outmigration and changes in disposition toward migratory behavior that may occur with time in the development from fry (spring) to fingerlings (summer) were evaluated against the general standard of increased survival with increased size at release as published for chinook and coho smolts.

Table 11. Temperature units (°F) accumulated at various stages of development.

Brood Year	CTU (F°-32)	Comments
Eye Up	500	As low as 465 in 1990
Hatching	1000	
Swim Up	1400	
1986 1st spawn	992	90% hatch
1986 2nd spawn	1072	90% hatch
1987 3rd spawn	957	Hatching observed
1988 1st spawn	961	Hatching observed
1990 1st spawn	465	Visibly eyed
1990 1st spawn	1144	1/3 hatched
1996 1st spawn	969	Hatch
1996 2nd spawn	990	Hatch
1996 3rd spawn	977	Hatch
1996 4th spawn	989	Hatch

Mean length has not been determined at swim up. Fry are allowed to volitionally swim up from substrate and exit Nopad incubators into fry rearing troughs (see Section 4.3). Mean dates of volitional swim up have occurred from mid-April to the latter part of May in four years observed from 1989 to 1997 (Table 12). Fry size at first feeding has averaged 0.18 ± 0.01 grams among years measured (Table 12). Length at swim up has not been measured. Differences between lake and tributary temperatures and anticipated effects on development were discussed in Section 3; Table 8.

Table 12. Dates of mean volitional swim up.

Date swim-up	Size (grams)
May 11, 1989	0.160
April 26, 1991	0.160
May 24, 1993	0.160
April 29, 1997	0.167
April 16, 1998	0.250
April 28, 1999	0.180

8.5) Fish Health monitoring:
Describe any diseases, yolk-sac malformation, and mortality.

A 12-year pathogen history is shown below in Section 8.12 (Table 13). Although pathogens were detected in brood stock gametes in several years, clinical disease problems were limited to the IHN outbreak in 1993 (progeny of brood year 1992). Isoincubation, segregation, improved and increased iodophor disinfection, combined with stress reduction strategies, have helped to reduce the possibility of a recurrence of an IHN epizootic in fry.

REARING:
8.6) Number of fish ponded and survival objective to release:

The overall number of swim up fry ponded (1,201,363) was previously shown for the past 12 years (Table 9; Section 8.1). The inter-annual grand mean ± SEM was 100,114 ± 23,967 fry ponded among collection years, with a range of 10,148 - 270,287, n = 12. The overall total number of progeny released from 1986 to 1998 was 1,032,876. The inter-annual grand mean ± SEM was 86,073 ± 25,547 progeny released among collection years, with a range of 0 - 266,295, n = 12.

Although future survival rates are expected to exceed past average rates because causes for most of the mortality in the past have been eliminated or reduced, the minimum survival objectives will be the actual green to eyed, eyed to swim up, and swim up to release survivals over the past 12 years, which have averaged 83.9%, 98.3%, and 86.0%, respectively (Section 10.3.2; Table 18).

8.7) Density and loading:
Include a description of the rearing containers, such as start tanks, circulation, circulating ponds, flow through, etc. Refer to section 4.4.

Upon releasing unfed fry, if this strategy proves to be successful based upon monitoring, remaining fry will be retained in shallow, fiberglass start tanks at low density for feeding, if a fingerling release strategy is warranted. Fry will then be split into covered, ten-foot-diameter, circular, fiberglass tanks for final rearing at low densities. The maximum load of 20,000 fry per tank would be approximately 0.3 pounds per ft^3 at a release size of just under one gram. We will keep all rearing densities below 0.5 pound per ft^3 with a mean target release size of less than one gram (454/lb).

8.8) Influent and effluent gas concentrations:
(oxygen, carbon dioxide, total gas pressure).

Dissolved oxygen will be at or near saturation (10 to 11 ppm). See Section 3.

8.9) Length, weight, and condition factor.

Not measured as of 1999.

8.10) Growth rate, energy reserves:
(hepatosomatic index - liver weight/body weight) and body moisture content as an estimate of body fat concentration).

Fry increase their mean weight approximately six-fold in the 60-day period prior to release at one gram. Hepatosomatic index and body moisture content have not been measured as of 1999.

8.11) Feed type, amount fed, and estimates of feed conversion efficiency:

Fry are fed Nutra Plus and Nutra Fry, a low moisture commercial diet produced by the Moore Clarke Feed Company, Washington. The daily feeding ration will be presented to fry by Ziegler automatic belt feeders ranging from 1% body weight/day, until fry are actively feeding, to 4% body weight/day, as rearing temperatures peak in late-May to early-June just prior to fingerling releases each year. Human contact with the fry will be minimized which is facilitated with the automatic feeders. Feed conversion ratios range from 0.75 to 0.95 during the 60-day rearing period.

8.12) Health and disease monitoring:

Adult certification is provided through the NWIFC Fish Health Laboratory pathologist. Adult tissue samples (one-to four-fish pools each for: coelomic fluid, kidney/spleen, and milt) are collected from 100% of the spawners. These are then analyzed using the guidelines established in the Salmonid Disease Control Policy of the Fisheries Co-Managers of Washington State. Survival and health of swim up fry will be monitored throughout the rearing period by MFM in conjunction with the NWIFC pathologist. Juveniles receive a monthly fish health examination. This prophylactic exam includes, at minimum, a microscopic assessment to monitor gill and external parasites, and a general assessment of fish health. More frequent or extensive exams are available on an as needed basis to be determined by the disease subpanel, MFM, and the NWIFC pathologist. The juveniles also receive a pre-release final examination.

Table 13. Lake Ozette sockeye pathogen history at Umbrella Creek Hatchery 1/1/88 to 12/31/99.

Year	asal	bgd	cos	cys	egd	eibs	fcol	fpsy	gbug	hexa	ihnv	ipnv	mal	pflu	pmv	reov	rsal	sbug	vhsv	yruc
1988											+	-			-	-			-	
1989											-	-			-	-		-	-	
1990											+	-			-	-			-	
1991	-		+		-	+	-	-			-	-		-	-	-		-	-	-
1992	-	-	-	+	+		-	-	-	-	+	-		-	-	-		-	-	-
1993	-	+	-		-		-	-	-		+	-		-	-	-		-	-	-
1994	-	-	-		-		-	-	-		-	-		-	-	-		-	-	-
1995		-	+		-				-		-	-			-	-		-	-	
1996		-	-		-				-		-	-			-	-		-	-	
1997	-	-	+	+	-		-	-	-		-	-	+	+	-	-		-	-	-
1998	-		-		-		-	+	-		-	-	+	-	-	-		-	-	-
1999	-	-	+		-		-	-	-					-				-		-

asal	*Aeromonas salmonicida*	
bgd	Bacterial gill disease	1993: This was a secondary infection during IHN mortality.
cos	Costia	1991, 1995 & 1999: Very few found on gills; 1997: skin infestation treated with formalin.
cys	Coagulated yolk syndrome	1992: Found 1 fish with coagulated yolk. 1997: coagulated yolk due to early handling causing some mortality.
egd	Environmental gill disease	1992: Minor gill hypertophy reported.
eibs	Erythrocytic inclusion body syndrome	1991: Red blood cell inclusions were found the one time they were looked for, no disease was evident.
fcol	*Flavobacterium columnaris*	
fpsy	*Flavobacterium psychrophilum*	1998: One mortality had tail erosion and systemic infection due to F. psychrophilum.
gbug	No parasites were found on the gills	
hexa	Hexamita	
ihnv	Infectious hematopoietic necrosis virus	Adult samples: 1988: 57 of 57 samples (+); 1990: 1 of 4; 1992: 12 of 12. Juvenile epizootic in May 1993.
ipnv	Infectious pancreatic necrosis virus	
mal	Malnutrition	1996: Found 1 malnourished fish; 1997: off feeding too long before tagging.
pflu	*Pseudomonas fluorescense*	1997: Secondary infection to coagulated yolk.
pmv	Paramyxovirus	
reov	Reovirus	
rsal	*Renibacterium salmoninarum*	
sbug	No skin parasites were found	
vhsv	Viral hemorrhagic septicemia virus	
yruc	*Yersinia ruckeri*	

8.13) Smolt development indices, if applicable:
(e.g. gill ATPase activity).

Not applicable.

8.14) Use of "natural" rearing methods:

Eyed egg plants or early fry releases greatly minimize exposure to the artificial hatchery environment; however, feeding fry to a one gram fingerling size is also expected to have minimal domestication effects, particularly with the rearing strategies described below. Under current methods in the hatchery, eyed eggs are cleaned, inventoried, and consolidated by expected hatching date, and by spawning aggregation, into Nopad-style bulk incubators. These incubators contain a layered combination of polyethylene filter fabric and Bio Rings® to provide a rugose substrate for the newly-hatched fry. The incubators are configured to allow buttoned up fry to voluntarily exit the incubator and emigrate to an initial rearing container illuminated solely by natural lighting available within a roofed, open-walled building at the Umbrella Creek Hatchery. Once the fish have entered this container, an automatic belt feeder continuously presents feed throughout the daylight hours. Human exposure is very limited to minimize conditioning and domestication but includes a once daily hand feeding while the automatic feeders are loaded, daily mortality removal, bi-weekly weight monitoring, and a monthly fish health examination.

When the satellite hatching and imprinting site is constructed at the proposed site on Big River, future methods may include late incubation and hatching in natural substrate in RSI's, volitional swim up, emigration into a natural rearing pond, natural rearing, feeding, imprinting, and volitional outmigration.

8.15) Unknowns:
Describe data gaps that lead to uncertainty in the incubation and rearing protocols.

Rearing fry for 60 days should not appreciably increase domestication and may increase survival by compensating for reduced growth rate due to cooler tributary incubation temperatures. The highest adult returns to Umbrella Creek to date resulted from the latest and largest juveniles released. This rearing strategy also produced a high homing rate to the rearing site. However, the first returns to Umbrella Creek resulted from unfed fry releases and no comparisons have been made among these different strategies using comparable release numbers or under similar release conditions. We propose to compare relative survival of 50,000 unfed or early fed fry and 50,000 fed fingerlings in a spring 2001 release into Umbrella Creek (Section 9.6). A preliminary power analysis was completed by Marianna Alexandersdottir, biometrician for NWIFC, to determine the effective sample size needed to accomplish this study:

Power Analysis for Lake Ozette Sockeye Fry/Fingerling Release Study.

The null hypothesis for a release of two groups of 50,000, each marked with unique otolith marks, is that the two release types will return in equal proportions. Therefore, any sample taken during brood stocking or carcass surveys should have equal numbers of each otolith mark. The alternative hypothesis is that one release type (say type A) survives to return at a higher rate, therefore a higher proportion of otoliths found in any sample would be of type A.

The question is: Can this null hypothesis be tested given the numbers of otolith marked fish sampled? Table 14 shows expected power for a range of possible differences and sample sizes. The important parameters in Table 14 are:

Sample Size – N(1). Each row represents a different sample size. This is the number of otolith marked fish actually found in the brood stock or carcasses examined. Therefore, if 100 pairs of fish are taken for broodstock, i.e. 200 fish, but only 5% are from hatchery releases and 10 fish with marked otoliths are recovered, thesample size is 10 fish. The sample size will depend heavily on the proportion of the total return that is from hatchery releases.

Effect Size: Each column represents a different effect size. This is expressed in three ways;

- The proportion of each otolith actually observed in the sample, which is expressed in the column header, for instance, as Prop = 0.60. So, the sample proportions evaluated here range from 0.6 to 0.8.
- What different survivals would result in those observed proportions, which are represented in the two top rows for Group A and B. Group A is the group that survives at the higher rate and so would be the larger proportion in the sample. In this example, Group A was fixed at 0.5% and Group B was varied from 0.33% down to 0.13%.
- The effect size expression of most interest is the ratio of the survivals, i.e. when the proportion of Group A is at 0.6 (or 60%) then Group A is surviving at 1.5 times higher rate than Group B. When Group A is observed as 80% of the sample, then it is surviving at a rate 4 times that of Group B.

Power: The numbers in the body of Table 14 represent the power. Power is the probability that a significant difference will be detected, given the sample size (N(1)) and the effect size (or real difference between groups). So if in fact Group A is surviving at 1.5 times the rate of Group B and the sample size is 10 otolith marked fish, there is only a 0.098 probability of detecting that difference, or a 9.8% chance. In general, when designing an experiment, an expected power of at least 0.80 or 80% is desired.

Results: Table 14 shows that if in fact one group has a survival rate 1.5 times bigger than the other, 195 otolith marked fish are needed in the sample before power exceeds 0.80 or 80%. If the higher survival rate is 1.86 times larger, the sample size needed is 85 otolith marked fish. At 2.03 times larger, the sample size needed is 70 otolith marked fish. At three times higher survival for one group, 30 otolith marked fish are needed. At four times higher, the sample size needed falls to 20 otolith marked fish. **The sample size is not the number of fish taken for brood stock or carcasses found, but rather the number of fish found with otoliths.**

So, if there is a big difference, with one group surviving at two to four times the rate of the second group, a sample size of at least 70 otolith marked fish will detect these differences. In order to detect smaller differences, more otolith-marked fish need to be sampled.

A survival rate from release to adult in hatchery fish of 0.5% for each of the twin releases of 40,000 fry and 40,000 fingerlings, as proposed in Sections 8.15 and 9.6, would yield 200 otolith-marked adult returns per release. While these sample sizes have adequate power to discriminate significant differences among the two release treatments, they are minimal and should not be reduced (or possibly, they should be increased). It is important to understand that although there may be 200 adults returning to the creek from each release group, the actual number of otolith-marked adults sampled will be less. This is because future samples collected from brood stock and carcasses will be representative of all adults returning to the creek, which will include significant numbers of NOR's that are not otolith marked and would not therefor contribute to the experimental sample.

Table 14. Power expected for comparison of fed fry and fingerling survival from release to escapement at different sample sizes and effect sizes.

Survival Group A:	0.50%	0.50%	0.50%	0.50%	0.50%
Survival Group B:	0.33%	0.27%	0.25%	0.17%	0.13%
Ratio (A/B):	…….1.50	1.86	2.03	3.00	4.00
N (1)	Prop= 0.60	Prop= 0.65	Prop= 0.67	Prop= 0.75	Prop= 0.80
10	.098	.161	.195	.381	.530
15	.122	.219	.269	.527	.703
20	.147	.276	.342	.649	.821
25	.172	.331	.411	.745	.896
30	.197	.386	.476	.818	.941
35	.222	.438	.537	.872	.968
40	.247	.487	.593	.912	.983
45	.272	.533	.643	.940	.991
50	.296	.577	.689	.959	.995
55	.321	.618	.730	.973	.998
60	.345	.655	.766	.982	.999
65	.368	.690	.799	.988	.999
70	.392	.722	.827	.992	1.000
75	.415	.751	.852	.995	1.000
80	.437	.778	.873	.997	1.000
85	.459	.802	.892	.998	1.000
90	.480	.824	.908	.999	1.000
95	.501	.844	.922	.999	1.000
100	.521	.861	.934	.999	1.000
105	.541	.877	.945	1.000	1.000
110	.560	.892	.953	1.000	1.000
115	.579	.904	.961	1.000	1.000
120	.597	.916	.967	1.000	1.000
125	.615	.926	.972	1.000	1.000
130	.632	.935	.977	1.000	1.000
135	.648	.943	.981	1.000	1.000
140	.664	.950	.984	1.000	1.000
145	.679	.956	.987	1.000	1.000
150	.694	.962	.989	1.000	1.000
155	.708	.967	.991	1.000	1.000
160	.721	.971	.992	1.000	1.000
165	.735	.975	.994	1.000	1.000
170	.747	.978	.995	1.000	1.000
175	.759	.981	.996	1.000	1.000
180	.771	.983	.996	1.000	1.000
185	.782	.986	.997	1.000	1.000
190	.793	.987	.998	1.000	1.000
195	.803	.989	.998	1.000	1.000
200	.813	.991	.998	1.000	1.000

Also, changes in environmental conditions and life history traits may alter fed fingerling outmigration in early summer from that of natural emergent fry in April. Of 27,365 fry released at RM 4.5 in late June 1999 , only 9,025 (33%) were later recaptured by fyke net at RM 1 (Figure 25; Section 10.4; Monitoring Release). Reduced flows and observations of fingerlings exhibiting positive rheotaxis may have inhibited outmigration, but additional confounding occurred due to poor trap efficiency, which ranged from 44.8% to 82.4%, before and after the hatchery release. The goals of this HGMP are to optimize rearing conditions and duration to maximize survival without imparting undesirable hatchery traits. Our monitoring component will evaluate which of the rearing strategies are best to increase survival of the ESU.

SECTION 9. RELEASE

Provide current and previous goals and data. Include historic data for three generations or for years dependable data are available. Also, describe any inconsistencies with standards and guidelines provided in any ESU-wide hatchery plan approved by the co-managers and NMFS.

Release procedures will be conducted to minimize ecological and genetic changes that may occur in the artificial environment and to preserve the natural variability, fitness, and long term survival of the wild population as described in Hard *et al.* (1992). The current release strategy is to reintroduce and supplement sockeye in areas where there is productive spawning and incubation habitat to result in increased abundance, productivity, spatial structure, and diversity of the ESU; or where there is evidence of historic spawning.

Currently these efforts will be focused on supplementation and reintroduction in Umbrella Creek and reintroduction to Big River using tributary stock. Pending research on limiting factors and factors for decline of beach spawners and their progeny, genetic status, spatial structure, and life history of adults during holding and spawning in the lake; future lake supplementation of existing spawning aggregations and reintroduction to unutilized beaches will employ the same strategy as described above to increase viability of lake spawners. These strategies are designed to maximize the productive potential of known existing spawning habitat while minimizing risks associated with (1) collecting wild brood stock and (2) reintroducing sockeye to habitats which have an uncertain ability to sustain them.

Background:

The successes realized by the current supplementation program began with adult returns to Umbrella Creek in 1991 and 1992. These returns resulted from brood year 1987 and 1988 unfed and fed fry releases. No adult sockeye were observed spawning in Umbrella Creek, other than in the historical record, prior to 1991. These releases were responsible for the first recorded observations of tributary spawning sockeye in the Lake Ozette system in recent times. Significant evidence of natural reproduction occurred in 1996 when Umbrella Creek four-year-old adult returns of 49 fish per mile surveyed were observed four years after the 1992 brood year, when no hatchery sockeye were released. Because no hatchery progeny were released in 1992, and returns are predominantly four years old, these 1996 adults provided the first strong evidence for the presence of NOR's. New NOR data currently under collection in the 2000 return combined with the NOR data previously discussed in Section 2.2.3 from other recent years has provided considerable evidence for an increasing spawning aggregation of NOR's in Umbrella Creek.

Beach spawner surveys conducted in 1998 found only 2/165 (1.21%) beach spawners sampled from the beaches that were fin-clipped, despite the fact that fed fry were released directly off of the beach. Both clipped fish were found on Olsen’s Beach near the release site and none were found on Allen’s Beach. An expansion for unmarked fish suggests that approximately five percent of the beach spawners in 1998 were of first generation hatchery origin from this nearby lake fry plant. The majority of the returning hatchery origin adults returned to Umbrella Creek where early imprinting on the hatchery water source influenced their return. This release strategy has been discontinued.

Recovery of eyed eggs from three sockeye redds at RM 4 in Umbrella Creek was accomplished in February of 1999 in a one-time redd-pumping procedure, as the first evidence of NOR reproductive success in Umbrella Creek. A demonstration of the use of the Dungeness River redd pumping euipment was given to MFM on 2/9/99 by the Hatchery Manager and two volunteers from the WDFW Hurd Creek Hatchery. Two sites were selected in Umbrella Creek, one redd was pumped at the first site (RM 3.5), and two redds were pumped at the second site (redds flagged week 48; 11/23/99 to 11/25/99; RM 4). In the first redd, 142 total eggs were recovered, of which 53 (37.3%) were alive and 89 (62.7%) were dead. At the other site, few eggs were recovered from two redds. Only seven eggs were recovered from the first redd but 6/7 (85.7%) were alive. Of 32 eggs recovered from the second redd pumped at RM 4, 24 (75%) were alive. Samples were retained for genetic or otolith analyses. Although it may be a coincidence, and in consideration that very low numbers of redds were compared, it was observed that there was a relatively high amount of fine sediment on the redd pumped at RM 3.5, which had the lowest survival rate. Survival rates of eggs are expected to be considerably lower in nature than were observed here, so it was assumed that other dead eggs were not detected; however, it may also be presumed that this dead egg loss would be similar among the three redds pumped.

Recovery of approximately 5,000 subsequent outmigrating swim up NOR fry was accomplished by Makah Fisheries Management using fyke nets (Figures 16 and 17) from mid-April to mid-May, 1999, before any hatchery fish were released into Umbrella Creek. Actual NOR fry abundance was postulated to be considerably higher because the outmigration was already underway when trapping was initiated on April 14, 1999, and because trapping was interrupted on numerous occasions due to flooding, beginning in early May, when a majority of the fry were expected to be emigrating. In addition, trap efficiency was very poor, averaging approximately 50% using much larger one-gram fed fry, which were presumed to be easier to trap than smaller swim up fry.

Finally, adult returns in the fall of 1999 to Umbrella Creek were monitored by collecting carcasses and spawn outs. Sockeye releases into Umbrella Creek have resulted in a tributary spawning aggregation comprised of a growing number of natural origin recruits (NOR's) and F1 hatchery returns (Table 7; Section 2.2.3).

In 1999/2000, the tentative estimated sockeye escapement in Umbrella Creek was 400. It was calculated that approximately 37.2% were NOR's based upon adipose clips. Of the escapement of 400 adults to Umbrella Creek in 1999/2000, approximately 149 were of natural origin (400 x 0.372). The estimated 101 and 149 adult NOR's in 1996 and 1999, respectively (Table 7), and the 1995/1999 spawner replacement ratio of 2.7 indicate a definitively increasing trend in reproductive success in the Umbrella Creek sockeye spawning aggregation.

In 1996, a total of 128 adults were captured from Olsen's Beach and 0/128 (0%) were found to have adipose clips. This demonstrates that straying is very low when fish are reared and released into the tributary. This suggests that any attempts to reestablish NOR's at locations outside of Umbrella Creek must eliminate the opportunity for imprinting to the hatchery site if reintroduction is to succeed. This indicates avoiding any hatching or rearing at the Umbrella Creek Hatchery for outplants beyond Umbrella Creek. All reintroduced fish will either hatch in incubators planted in gravel at the release siteor preferably, within RSI's at a proposed future satellite hatching and imprinting release site on the Big River drainage.

Accordingly, releases into the lake and tributaries other than Umbrella Creek will be slated for eyed eggs to improve imprinting on the release location whereas fry and fingerling plants will be targeted for Umbrella Creek. The goal is to have the stray rate of tributary-origin adult returns to lake beaches remain less than 1%.

We propose to continue reintroduction and supplementation in Umbrella Creek and Big River, comparing post-release survival of eggs, fed, and unfed fry and fingerling releases by employing differential otolith marking for each of these three life history release strategies, and adipose fin clipping fed fry and fingerlings. Initiation of a comparison of unfed fry and fingerling postrelease survival is proposed for the 2001 release (Section 9.6). Any strategy that does not prove to be effective, or as effective as an available alternate strategy, will be discontinued. Otoliths will be recovered from a sufficient number of brood stock and carcasses as possible that can be recovered from Umbrella Creek and from as many smolts or fry sampled as necessary. Relative proportions of wild and hatchery fish, including contributions of each release strategy, will be determined through this monitoring.

Current Release Strategies:

Brood stock selection in Umbrella Creek in 2000 and beyond will be based on a random collection of the total run, including natural origin recruits and hatchery origin fish. Under the brood stock take guidelines which maximize the total inbreeding effective size of the spawning aggregation, we will limit take to 40 pairs of fish for supplementation of Umbrella Creek in 2000. We will limit take of brood stock in Umbrella Creek for reintroduction to Big River to 60 pairs in 2000. This total take of 200 brood stock in Umbrella Creek is projected to be less than ten percent of the spawning aggregation in the creek in 2000 (MFM unpublished data). This total take proposed for 2000/2001 meets the guideline of not exceeding 15% take of the spawning aggregation for supplementation (which was for Umbrella Creek only), and does not exceed other initial numerical guidelines for brood stock collection (100 pairs total) as mentioned in Section 5. This will allow for growth of the natural spawning aggregation in Umbrella Creek. Furthermore, if adult sockeye are approved for removal from Crooked Creek in 2000 through 2003, this will additionally help to bolster natural production in Umbrella Creek by reducing take of natural spawners.

In 1999, due to the conservative capture and retention methods employed, the eggs of only 12 females were collected and 1:1 matrix spawned with males from Olsen's Beach. This resulted in approximately 30,000 eyed eggs which were divided in half for the purpose of accurately assessing egg hatching survival in replicated incubators on lake beaches and in Big River and to demonstrate high survival egg planting methods. Lake incubators were anchored above lake substrate and survival was determined from eyed egg to hatching using 15 incubators @ 400 eggs/incubator (200 cells at 2 eggs per cell). Artificial substrate was placed below incubators in gravel encased with an anti-predator screen between incubator and gravel (Section 4.5). Similarly, egg survival in Big River was determined in incubators buried in cleaned gravel and survival determined from eyed egg to hatching using 15 incubators @ 400 eggs/incubator (200 cells at 2 eggs per cell). Survival was determined by recording the number of dead eggs in each incubator that could be visibly observed. No adjustment was made to account for eggs that decomposed and were subsequently not seen when hatching success was determined.

There is no release strategy planned in the lake in 2001 or 2002 other than for the small number of eggs planted in baskets for replicated studies of egg survival on the beaches. For 2000/2001 brood year and 2001/2002 release year strategies in Lake Ozette, no more than five spawning pairs will be used from each beach to study limiting factors in sub-habitats on lake beaches (new and source beaches). Egg survival, from green to eyed and from eyed to swim up, will be measured in baskets buried in lake substrate in different habitat subtypes.

Pending results of ongoing and proposed research, an abundance-dependent release strategy that minimizes risks may be implemented (Appendix D). Lake stock will be used exclusively for lake plants. Investigations of the limiting factors affecting egg survival among different incubation sub-habitats, beach spawner abundance, productivity, and spatial distribution of the spawning habitat utilized, and genetic analysis of spawners at each beach spawning location; will precede future supplementation and/or reintroduction efforts on the beaches.

Any future outplants to unused beaches will be abundance based. On lower production years, only supplementation of existing spawning aggregations would be proposed. We propose a stepped experimental approach for considering future lake plants, including Olsen's and Allen's Beaches. This strategy will use population abundance to determine the number released, whether releases will be conducted on other beaches (pending research results and consensus), and the threshold below which no higher risk strategies will occur.

Comparisons of post-release survival can be made in upcoming years among past year release strategies which included eyed eggs only in some years (1996 and 1999), which can be compared to other years that included eggs, fed fry, and fingerling releases (1997 and 1998).

9.1) Life history stage, size, and age at release:
Give averages with distribution.

Table 15. Size, age, and stage at release.

Brood Year	Size (g)	Age (days)	Stage	Brood Year	Size (g)	Age (days)	Stage	Brood Year	Size (g)	Age (days)	Stage
86	1	49	F	91	1	89	F	97	nd		e
87	0.2	17	f	93	1	73	F		1.9	63	F
	1.2	67	F	94	1.3	85	F	98	nd	nd	e
88	0.1	1	f	95	1.1	80	F		1	70	F
	1.1	66	F	96	nd	0	e	99	nd	0	e
90	1.9	94	F		1	60	F		1	70	F

F = Fed fry   f = Unfed fry   e = eyed egg   nd = not done
1989 missing because no brood stock were collected due to conservation concerns.
1992 missing due to IHN virus.

Unfed hatchery fry have averaged 0.15 ± 0.05 grams and are released within a few days post swim up. Fed fry have averaged 1.21 ± 0.10 grams at release which has averaged 72 ± 4 days post swim up. Natural swim up fry in tributaries appear to be identical in size and emerge in Umbrella Creek at the same time as hatchery fry. The size at emergence of natural fry hatched on lake beaches has not been measured but is expected to be the same as the emergence size of lake-origin fish hatched at the Umbrella Creek Hatchery or in Umbrella Creek (0.15 ± 0.05 grams). Emergence timing of tributary and lake swim up fry was compared toward the end of Section 3 and in Section 8.4 below (Table 11).

9.2) Life history stage, size and age of natural fish of same species in release area at time of release:

No size or age data has been collected for naturally-produced juvenile Lake Ozette sockeye from release sites during past releases. However, since beach aggregations spawn at the same time and up to 2.5 months later than tributary spawners, life history stage and age are expected to be similar between lake and tributary origin fry. Size appeared to be identical between hatchery fry and wild sockeye swim up fry egressing from Umbrella Creek in April and May of 1999, based upon visual observation. Time to egg eye up is expected to be similar between eggs incubated at Umbrella Creek, Umbrella Creek Hatchery, MNFH hatchery (12 days later than lake beaches) and lake beaches and very similar between eggs incubated at Educket Hatchery and lake beaches. Projected times to reach various stages of development for lake and tributary origin fish was examined in Section 3 and in Section 8.4. Fed fry and fingerlings shown below have ranged from 0.5 to one gram at release. It should be noted though that food availability in Lake Ozette is vastly under-utilized according to Beauchamp *et al.* (1995).

9.3) Dates of release and release protocols:
Specify whether release is volitional or forced.

Dates of release have varied and will continue to vary for each type of release. The first release each season will be eyed, otolith-marked eggs for reintroduction, which will occur from mid-February through March each season. The next release component will be otolith-marked, unfed fry which will be released each year from mid-March to late-April into Umbrella Creek, or in the future, possibly from an RSI in the Big River drainage. This would allow for volitional release as well as yielding other benefits as described below. These tributary unfed fry releases will be conducted during freshets after dusk to mimic the natural stream migration period of natural sockeye salmon fry. Fed fry and fingerlings will be reared to a size of 0.5 to 1 gram at the Umbrella Creek Hatchery, or in the future, possibly from an RSI/imprinting pond on the Big River drainage or at an upper portion of the Umbrella Creek watershed; and released from late-March to late-June each year. Adipose clipped, otolith-marked, fed fry and fingerling releases will be conducted at dusk during freshets, if possible, and preferably on the same release year in similar numbers to compare postrelease survival among different fry and fingerling release strategies.

Table 16. Hatchery release timing.

Release Type	Hatchery Release Timeline					
Eyed Egg	|----------------|					
Emergent Fry		|-----------|				
Fed Fry/Fingerling		|--|				
Month of release	Feb	March	April	May	June	July

Eyed egg plants are intended for reintroduction programs and are patterned after the successful Alaskan program of White (1986). Healthy, disease-free, eyed eggs from each isobucket will be disinfected with a 100 ppm iodophor solution and divided in proportion to provide equal genetic representation for each release strategy. Aliquots destined for each release strategy will receive a unique otolith mark.

Future eyed egg plants would be limited to reintroduction plants using an RSI or incubators in Big River, upper Umbrella Creek, or on lake beaches, if approved. Incubator plants will be conducted in a similar manner as employed in 2000. Other than eyed egg releases for reintroduction, natural fry releases may be accomplished at a satellite incubation and natural rearing site in the Big River drainage (planting eggs before hatching). These fry releases would culminate from eggs hatching in semi-natural habitat in RSI's, volitional ponding, fry imprinting, natural rearing and feeding, supplemental feeding, and volitional emigration.

For 2000, Jordan incubators were used to study eyed egg survival in incubators in Lake Ozette and Big River. For lake plants, the incubators were anchored to the lake bottom above an attached rugose substrate encased in an anti-predator screen over suitable gravel to allow exiting alevins refuge to hold and absorb yolk reserves. On February 15, 2000, 42 replicate incubators were stocked with 400 eggs per incubator (two eggs per cell; 17,300 eggs total including extra eggs), incubators were grouped in blocks of five and in one block of two and then housed inside three trough-type trout egg baskets which allowed alevins to exit. Scuba divers planted these incubators in approximately seven feet of water on the outer boundary of spawning gravel on Olsen's Beach. Each basket was ballasted with two to three inches of 2.5-inch minus gravel. In addition, an eight-inch area surrounding the incubators was filled with one-inch Bio Rings®s. Everything was encased in heavy duty, 1/4 –inch vexar to prevent predation. During the same time, aliquots of the same egg takes were divided and loaded into 44 Jordan incubators at 400 eggs per incubator (two eggs per cell; 17,575 eggs total including extra eggs) and buried in Big River in eight to ten inches of cleaned gravel in appropriate pool tail-outs and riffles, and secured with cable attached to anchor bars.

Eyed egg to swim up survival rates were high in lake (96%) and in Big River (98%) incubator plants in 2000 (see Monitoring Release under Section 10.4). Survival in lake incubators in 1999 was also high (99%). Applying this eyed egg to emergence survival rate of 98% to the 12-year average green to eyed egg survival of 83.9% at Umbrella Creek Hatchery, a total, minimum spawning to emergence survival rate of 82% is expected for reintroduction programs based on the average survival rates realized using past hatchery methods. Green egg survival to emergence in the Cedar River, Washington, has ranged from 2 to 20 percent (Dr. E.L. Brannon personal communication). Although natural egg survival rates to emergence are lacking on lake beaches, if survival rates are comparable to those observed in the Cedar River, we may expect a 4 - to 40 - fold increase in survival using hatchery methods and Jordan incubators for outplanting over natural survival to emergence in Big River or in the lake.

Depending on research findings in upcoming years, i.e. if gravel treatments are found to improve incubation survival; this substantial increase in survival of the ESU may be particularly meaningful because the eggs will be reintroduced to unused or underutilized, more productive, habitat which will facilitate productivity, increase spatial distribution of spawning areas, and increase diversity, in addition to increasing abundance, as previously described. These are the expected benefits of egg plants over not intervening with current spawning and redd superimposition on very limited lake beach habitat comprised of very high levels of fine sediment (MFM unpublished data).

Sufficient numbers of eyed eggs used in RSI's and incubator plants will be differentially otolith marked for each release strategy and loaded at low density. Planting eyed eggs at low densities into artificial substrate or optimal natural substrate in RSI's or into plastic, partitioned compartments in Jordan incubators allows for separation of groups, provides the interstitial spaces needed for healthy development, and enables replicated determinations of embryonic development and hatching success. It also allows eggs to hatch under conditions where alevins can volitionally emigrate from the incubators into the substrate, and permits alevins and swim up fry to imprint to their reintroduced habitats.

If fine sediment levels and egg incubation survival are found to be limiting factors, it may be necessary to clean or replace portions of lake beach substrate; beginning with small, replicated experimental tracts. Larger production egg plants may be warranted and initiated in the future to restored beach substrates using larger incubators, or eggs may be planted into cleaned gravel using a pump and hollow cylinder to plant eggs directly into the substrate.

9.4) Location(s) of release:
Provide specifications to allow GIS entry.

Release locations are dependent upon the particular life history stage and abundance-based release strategy being implemented. Eyed egg releases are also dependent upon spawning gravel locations, which change over time. Release locations will be recorded with sufficient detail to allow input to GIS.

Selection of the planting sites will be determined by an assessment of habitat quality as established by Timber, Fish, and Wildlife (TFW) salmonid habitat criteria and by written and oral records of historical sockeye use. Future potential sites include, but are not limited to, RSI's on tributaries to Big River or upper Umbrella Creek, incubator plants in gravel in Big River (20.0058) and Umbrella Creek, as well as incubator plants above or within substrate on suitable spawning beaches where Ozette sockeye currently spawn or where they are currently extirpated, pending research results. All fry and fingerling releases are targeted for Umbrella Creek only.

9.5) Acclimation procedures:

No handling or temperature acclimation is required at the Umbrella Creek Hatchery for on station fry releases directly into Umbrella Creek from the rearing tanks because the water temperature of the hatchery water source is nearly identical to the ambient water temperature of Umbrella Creek. Location and development of a future acclimation and imprinting site is currently proposed in an unnamed tributary/side channel to Big River for final egg incubation and hatching in an RSI, volitional swim up and ponding, and subsequent natural rearing and volitional release.

9.6) Number of fish released:

Numbers of fish released in the past 12 years were shown in Table 3. The number of fish released in Umbrella Creek and Big River in upcoming years will vary with annual abundance and genetic guidelines (Section 5). For the 2000 return, we propose a take of 40 pairs from Umbrella and Crooked Creeks (2000 to 2003 only in Crooked Creek) for supplementation of Umbrella Creek, using guidelines and rationale described in Sections 5 and 9. Since recent brood stock survival rates have exceeded 90% and green to eyed, eyed to swim up, and swim up to release survivals over the past 12 years have averaged 83.9%, 98.3%, and 86.0%, respectively, it is anticipated that the 40 pairs, yielding 122,000 green eggs at fecundity of 3,050, would result in fry/fingerling releases in 2001 totaling approximately 80,000. We propose to evaluate survival of fed fry vs fingerling releases of 40,000 fish for each group in Spring, 2000. The survival objective is 0.6% or approximately 240 adult returns per release strategy (480 otolith-marked adult returns total). Since 195 otolith-marked returns are required to provide adequate power (>80%) to detect significant differences when release group survival rates differ by ≥ 50% (Section 8.15), these releases should provide adequate sample sizes. However, because NOR returns will be mixed in with the returns from these releases, the release numbers proposed (40,000) are projected to be close to the minimum required to enable a large enough sample size of marked otoliths in the returns for adequate statistical power.

We propose a brood stock take in Umbrella and Crooked Creeks for reintroduction to Big River of 60 pairs in 2001. This take will produce 183,300 green eggs. Using the brood stock survival rate of 90% and green to eyed survival rate of 83.9%, a total of 138,183 eyed eggs are projected for incubator plants into Big River in Spring 2001. The total take of 200 Umbrella Creek brood stock for all triutary plants is projected to be less than ten percent of the spawning aggregation in 2000, using preliminary forecasted numbers of spawners returning to Umbrella Creek (MFM unpublished data). Care will be given to ensure that the brood stock take in 2000/2001 remains below the guideline of not exceeding 15% of the spawning aggregation in Umbrella Creek or other numerical guidelines mentioned in Section 5 for supplementation or for reintroduction. This will allow for growth of the natural spawning aggregation in Umbrella Creek.

For brood stock collection on lake beaches in the future (pending research results as previously described), agreed upon numbers or proportions of brood stock to be collected will be determined as previously described.

9.7) Marks used to identify hatchery adults:

Hatchery fish will be identified with otolith marks which are unique to the particular release strategy employed. This includes eyed eggs for mitigation, supplementation, and reintroduction, as well as unfed fry, fed fry, and fingerling releases, depending on results comparing postrelease survival. It is not possible to externally mark eggs, unfed fry, or early fed fry, despite the necessity of monitoring these release strategies and the need to release fish at these stages. All fingerlings reared above a whole body weight of 0.5 grams will be adipose clipped and otolith marked.

9.8) Unknowns:

Describe data gaps that lead to uncertainty in the release protocols.

This project will monitor the effectiveness of different early-rearing and release strategies culminating in adult return ratios in areas deemed suitable for sockeye utilization but currently under-utilized or devoid of any detectable sockeye spawning activity. Egg plants are necessary for reintroduction to Big River until such time that an RSI and natural release site can be established enabling egg hatching and fry rearing before release into Big River. Future supplementation and reintroduction in the lake will also require egg plants to ensure imprinting and homing to the release site.

Observed advantages and disadvantages between unfed and fed fry releases discussed at the end of Section 3 should be evaluated relative to possible merits (increased survival presumed with increased size at release) or possible disadvantages (reduced flow during outmigration in summer and/or reduced predisposition to emigrate as fingerlings). Effectiveness will also be determined by the degree that different release strategies minimize or eliminate adult straying back to unintended lake beaches.

Releases in 2000 for offspring of brood year 1999 were limited to eyed egg studies of incubation survival in Big River and on Olsen's Beach. Future research experiments will entail small, replicated egg survival studies in baskets planted in gravel in different sub-habitats on lake beaches. These studies are intended to determine whether incubation survival on lake beaches is a limiting factor.

The potential of tributary-released hatchery fish straying to the spawning beaches must continue to be monitored. First, a sufficient number of fish will be otolith marked to enable accurate monitoring and evaluation (we will target 100% marking). Next, a sufficient number of fed fry and fingerlings will be adipose clipped (again, we will target 100% clipping of fish reared above a body weight of 0.5 grams). We estimate that more than 85% of the estimated run size had camera images clear enough to determine the presence or absence of adipose clips in 1999. This large number of fish monitored can be done non-obtrusively as a standard part of the monitoring program to determine the proportion of the total run that is comprised of hatchery fish and natural fish, approximately five to six months before spawning. These camera counts can be compared later to actual numbers of hatchery and wild fish enumerated in spawning surveys. As previously mentioned, camera estimates at the weir of the proportion of clipped hatchery fish in the run (estimated to be 13.2 % of the overall run in 1999) that were based on a small subsample of

138 video camera images (6.6% of the run in 1999), predicted that 274 (2,076 X 0.132) adult hatchery fish would return to Umbrella Creek. These estimates were very similar to the actual spawner survey estmate of 251 clipped hatchery returns that did spawn naturally in Umbrella Creek in 1999. The difference of 8.4% among weir and creek estimates may be at least partly explained by adult holding mortality in the lake.

Estimates of hatchery and wild productivity will continue to be measured annually, improved and refined each year. Based on these observations from the 1999 subsample and improvements since 1999 in the clarity of camera images due to repositioning the camera, the proportion of clipped hatchery and wild adults in the overall return is being determined from all visible camera images in the 2000 return. Survival rates measured in known numbers of hatchery fish released can help infer survival rates of wild fish. Estimates of NOR and hatchery replacement rates in the lake and tributaries can be generated.

Next, otoliths will be recovered and read from brood stock collected and from spawn outs and carcasses recovered, as necessary, in addition to fin clips, to accurately determine the contribution of wild and hatchery returns in all spawning locations and to address risks by monitoring stray rates. Mass otolith marking will enable more precise identification of hatchery fish, which can be confirmed by observations of fin clips in pre- and post-spawning adult returns. Since the program relies in part on egg and unfed fry releases, fin clips will not always be possible but will always be included as a portion of the total release annually. Since the numbers of fed fry and fingerlings will be known, the relative survival of lake - and tributary - origin NOR's and unmarked hatchery fish returning from other release strategies can be inferred and compared to this benchmark.

The number of unmarked, lake-origin returns passing the weir can be enumerated by annually detrmining the number of externally clipped and unclipped adults passing the weir and again during spawner surveys in the tributaries. The total numbers of unmarked tributary returns counted in spawner surveys can then be subtracted from the weir counts to reconstruct the run size of unmarked, lake-origin adult returns. The relative survival of clipped fingerlings to unmarked eggs, unmarked fry, and NORs can be compared annually. These relative survival rates can be compared to the actual numbers enumerated and eventually used to forecast returns of these various stock components at the weir for each spawning aggregation.

It will be more difficult to determine the reproductive success of lake spawners. Based upon the lake holding survival of adults observed in the ongoing sonic tagging experiments, complemented by hydroacoustic enumeration of spawners, snorkel and scuba spawner and redd surveys, using a redd disturbance area method to estimate the true number of redds to compensate for mass spawning, estimates of pre-spawning mortality can be applied to the run size of lake-origin fish to determine the number of lake returns that survive to spawn.

No straying to lake beaches was observed out of the 1999/2000 return of 400 adult spawners to Umbrella Creek. The fry release from this brood cycle was directly into Umbrella Creek from the facility. No other evaluations of straying have occurred. When Olsen's Beach fry were released near Olsen's Beach in 1995 (from BY-1994), it was found that the adult return comprised approximately 5% of the spawning aggregation in 1998 on Olsen's Beach, but none were found on Allen's Beach, suggesting that none strayed across the lake. The 5% that returned to Olsen's Beach, their release site, cannot be classified as a stray rate. Both release strategies resulted in fair numbers of adults returning to Umbrella Creek; however, fry releases directly into Umbrella Creek appear to have resulted in higher returns, with no straying observed. Funding has been procured to continue to determine genetic composition of beach spawners. In addition to comparing their composition, this may possibly help to estimate and account for any natural straying or gene flow among beach spawning aggregations, if it occurs. Annual brood stock collections, and spawn out and carcass sampling for otolith marks (including natural isotopic differences in otolith composition in addition to natural and thermally induced marks) in all spawning areas will greatly assist in monitoring spawners for any changes in proportions of natural spawning aggregations and to provide assurance that the calculations described above do not overlook significant numbers of tributary fish that could potentially stray to the lake beaches.

9.9) Adaptive Management (added by MFM):

No fry releases will be conducted in the lake or in tributaries other than Umbrella Creek. The only exception would be potential future fry releases in the Big River drainage from an RSI/imprinting and rearing pond but this would still include planting eggs with hatching accomplished at the release site.

Annual planning of release procedures will depend on the assessments of productivity resulting from previous release sites or strategies. As preferred sites and release strategies continue to be developed, the relevant co-managers and land owners will need to continue to schedule site access, equipment, and manpower needs in coordination with egg and fish growth and development at hatchery facilities.

SECTION 10. MONITORING AND EVALUATION OF PERFORMANCE INDICATORS

(Note: This section and Section 1.8 are being rewritten for compatibility with current work on performance indicators in the Columbia River Basin, and in the Hood Canal Summer Chum Hatchery Plan.)

This section describes how the benefit or risk performance indicators listed in Section 1.8 will be monitored and evaluated, including whether funding, staffing, and other support logistics are available or committed to allow full implementation.

The items below should be incorporated into the performance indicator list and the attendant monitoring and evaluation program.

10.1) Marking:

Describe types of mark(s) and the proportion of the program releases that will be marked. Include any marking of wild fish for comparative analysis.

All program fish will be otolith marked as eyed eggs. A sufficient number (targeting 100%) of fed fry and fingerlings above 0.5 grams in body weight will be otolith marked and adipose fin clipped from each release. Wild fish may also be marked as necessary to determine hatchery vs wild survival at various life stages. No marking of wild fish is currently planned because a reliable method of applying a mass chemical mark to small fish has not been approved by the FDA. Strontium marking would provide a means of mass marking wild, juvenile sockeye (Schroeder *et al.* 1995). Future prospects for procuring an INAD to strontium mark wild juvenile sockeye have been discussed with WDFW and may follow suit with other INAD requests from WDFW, if deemed necessary.

Perhaps one of the highest priorities is to procure and install a screw trap in the Ozette River to estimate overall fresh water and ocean survival and productivity. Estimates of overall marine and freshwater survival can be determined for natural beach fish and for natural-and hatchery-origin tributary fish by comparing proportions of wild and marked hatchery smolts recaptured with the screw trap. Similarly, hatchery returns can be compared to wild adult returns to measure comparative ocean survival and total survival rates of wild and hatchery fish, using known numbers of marked hatchery fish released that contributed to their observed return rate.

10.2) Genetic data:

Provide available and relevant genetic baseline information.

The NMFS has offered to provide existing allozyme genetic data or samples when possible from Lake Ozette sockeye beach spawners to complement ongoing genetic research. To help learn more about baseline genetic profiles of listed Lake Ozette sockeye salmon, and kokanee salmon, which are not listed, MFM and NWIFC have procured preliminary funding (Attachment 2; Section 12) to develop profiles from 6-8 microsatellite DNA loci from *O. nerka* spawning aggregations within the Ozette Basin. These profiles are necessary to guide brood stock selection and to monitor hybridization and gene flow among all spawning aggregations of *O. nerka* in the Basin.

10.3) Survival and fecundity:
Provide data on goals and past performances.

See below.

10.3.1) Average fecundity

Overall fecundity has averaged 3,097 ± 91 in 11 years measured from 1986 to 1998 (Table 17). No fecundity data is shown for 1989 because no adults were collected. Fecundity statistics from 1990 were omitted due to the use of partial spawners. Fecundity will be measured from each eggtake.

Table 17. Mean fecundity over 11 years.

Brood Year	Fecundity
1986	2,952 ± 452
1987	3,563 ± 304
1988	3,094 ± 169
1991	3,457 ± 646
1992	2,718 ± 128
1993	2,592 ± 642
1994	2,535 ± 200
1995	2,296 ± 385
1996	3,267 ± 110
1997	3,232 ± 212
1998	3,020 ± 70

10.3.2) Survival

a) Collection to spawning

Shown below (Table 18).

b) Green eggs to eyed eggs

Numbers of green eggs, fry ponded, fry and fingerlings released, and their respective survival rates were previously shown in Section 8.1. The green to eyed survival rate over three generations has averaged 83.9%. The green to eyed egg survival rate will be measured upon shocking eyed eggs at the incubation facility prior to planting annually.

c) Eyed eggs to release

Eyed egg to swim up survival has averaged 98.3% and swim up to release has averaged 86.0% over 12 years (Table 9; Section 8.1.). Green to swim up and swim up to release survival rates are shown below). Survival from eyed egg to release will be recorded at Umbrella Creek, in egg incubators, and at any future RSI/natural rearing ponds. Eyed egg to emergence survival in incubators in 2000 averaged approximately 98% in the lake and in Big River as previously described toward the end of Section 9.3.

d) Release to adult, to include contribution to

(i) harvest

N/A

(ii) hatchery brood stock

Adult hatchery returns to Umbrella Creek were only recently differentiated from NOR's as discussed in the Introduction and in Section 2.2.3 (Table 7). Based on conservative escapement estimates over the last three return years (1997 to 1999), survival from fed fry/fingerling (approximately one gram) to adult spawner in Umbrella Creek has ranged from 0.22% to 0.88, averaging 0.5%. Adult replacement rates were only recently estimated in Umbrella Creek because they require escapement estimates of wild and hatchery adults in four-year intervals, which have only recently been determined and quantified. There were seven times as many returning adults in Umbrella Creek in 1999 than in 1995. Part of this increase was attributed to NOR's (2.7-fold), as previously described in Section 2.2.3 (Table 7). The determination of release to adult survival rates for all supplemented aggregations will be accomplished through sufficient marking of all hatchery releaes and otolith analysis of brood stock and carcasses, complemented with observations of the incidence of fin clips.

(iii) natural spawning

Natural origin recruit adult returns to Umbrella Creek were only recently quantified in 2000 and were discussed in the rationale and in Section 2.2.3 (Table 7).

Table 18. Survival by life stage over three generations.

Brood Year	Collection to Spawning	Green to Swim Up	Swim Up to Release
1986	100	87.6	29.7
1987	86.7	77.7	100.0
1988	71.1	74.9	98.0
1990	94.4	93.6	93.7
1991	21.1	79.2	87.1
1992	86.2	92.6	0.0 (IHN)
1993	96.9	85.7	94.9
1994	88.9	77.0	99.0
1995	53.2	76.1	96.4
1996	93.5	85.6	98.5
1997	62.4	94.1	98.8
1998	96.6	66.2	98.4

Brood stock collection and holding survival to spawning in 1999 was 96.6% (1/29). Of 121 beach spawners captured (74 males and 46 females), 91 (75.2%) were released upon genetic sampling, 28 (24%) were retained for brood stock, and one (0.8%) was a jack that was sacrificed and sampled for genetic analysis. In addition to the 121 captured, 20 were recaptured and also released (14.2%). None were clipped. A total of 27 were spawned. Most adults not collected were spawned out.

Overall collection to spawning survival from 1986 to 1998 averaged 72.1%. Most of the mortality occurred prior to 1992 when attempts were made to hold green adult sockeye for long periods in cages and in net pens to ripen in Lake Ozette. This has been discontinued. After 1991, brood stock were held in tanks at the Umbrella Creek Hatchery. In the 13 years from 1986 to 1998, a total of 371 mortalities occurred. Most of these losses (212 adults; 57.1% of the mortality) occurred during the five year period from 1986 to 1991 due to cage holding mortality (1988) and net pen holding mortality (1991). Of 506 fish captured through 1991, 41.9% resulted in mortalities. Since 1991, 782 fish were captured and 20.3% resulted in mortalities. Since 1991, adult mortalities at the Umbrella Creek Hatchery were primarily due to a freshet causing partial water failure in 1997 and partially due to jumping mortalities in 1995 when tank lids were left off. Lake holding has been discontinued, tank lids remain on, and increased personnel and monitoring of brood stock has been implemented, with potential 24-hour monitoring during severe freshets. Brood stock survival has also improved recently by collecting nearly-ripe adults and by not collecting spawning adults. This has also improved egg survival by avoiding over-ripe eggs.

Green to eyed egg survival has averaged 83.9%. Green egg to swim up (ponding) overall survival has averaged 82.2% with the inter-annual grand mean among the years 1986 to 1998 averaging 82.5% ± 2.5%, n = 12 years; ranging from 66.2% to 94.1%. The poor green egg survival in 1998 (66.2%) was due to employing a new technique of rinsing green eggs in a 17.3 ppt baking soda solution for the purpose of removing organic debris in peritoneal cavity fluid and for buffering pH prior to iodophor disinfection. This procedure has also been discontinued.

Swim up to release overall survival has averaged 86.0% with the inter-annual grand mean among the years 1986 to 1998 averaging 82.9% ± 9.4%, n = 12 years; ranging from 0.0% to 100%. The far majority of these losses occurred when progeny from brood year 1992 were destroyed after undergoing an IHN epizootic. Improved isoincubation quarantine facilities at Educket and at MNFH, reduced stress, improved sterile technique, improved disease control measures, including iodophor disinfection of eyed eggs in addition to disinfection of green eggs, and above all, isoincubation, have reduced the possibility that another IHN outbreak could occur. The cause for the low number released in 1986 is thought to be an inventory error and not due to mortality.

10.4) Monitoring of performance indicators in Section 1.8

The following are examples.

10.4.1) Proportions of hatchery spawners in natural populations in target area (list all populations or spawning areas that are monitored).

It was estimated that adult hatchery returns comprised 62.8% (range 47.5% to 78.6%) of the total return to Umbrella Creek in 1999 (approximately 21.4% to 52.5% were NOR's). Sockeye releases into Umbrella Creek have resulted in a tributary spawning aggregation comprised of a growing number of natural origin recruits and hatchery returns (Table 7; Section 2.2.3). The proportion of hatchery and NOR adult returns to Umbrella Creek in 1998 was not determined. Proportions of hatchery and natural adult returns were monitored in the Ozette River by the underwater video camera, on lake beaches and in Umbrella Creek in 1999 spawner surveys, and they will continue to be monitored in all spawning areas in the future. No hatchery-origin adult strays were found on Olsen's Beach in 1999 (0/121) from the 1995 tributary release. No hatchery adult returns were found on Allen's Beach in 1998 but approximately 5% were found on Olsen's Beach in 1998; however, fingerlings (progeny of brood year 1994) were planted near this beach as explained further in Section 10.4.4 below.

10.4.2) Ecological interactions between program fish and natural fish (same and other species) in target area.

Addressed below (Appendix C).

10.4.3) Disease control in the hatchery, and potential effects on natural populations.

Disease monitoring is addressed below and in Sections 4.3 (Incubation Facilities) which included safeguards to prevent disease for the Educket isoincubation facility to be used for egg incubation in 1999/2000 and 2000/2001. A full evaluation of using MNFH isoincubation quarantine facilities, beginning in 2000, was also described in Section 4.3 including a risk assessment which included a disease risk assessment and adaptive management actions developed by a disease subpanel, see Section 7.3 (Fish Health Procedures to Reduce Disease), Section 8.5 (Fish Health Monitoring), and Section 8.12 (Health and Disease Monitoring).

10.4.4) Behavior (migration, spawning, etc.) of program fish.

Adult behavior and migrational characteristics are described in Sections 2.2.1 and 2.2.2 and will be monitored extensively through data collected on adults entering the lake each year at the weir. Adult migration, behavior, mortality, and spawning distribution from lake entry to the end of spawning will be monitored by ongoing sonic/radiotagging experiments in 2000/2001 and 2001/2002 as described in the NMFS Biological Opinion for return year 2000 predation and survey studies in the Ozette River and Lake (Section 11- Research; Section 12 - Attachment 1). Juvenile migration (fry and smolts) will be monitored periodically by fyke netting as needed (fry; Figure 25) and annually by screw trap monitoring (smolts), as described below. Adult and fry timing are described above in Sections 3, 8.4, 9, 9.2, and 9.9.

10.4.5) Homing or straying rates for program fish.

The potential for tributary-released hatchery fish straying onto the spawning beaches will be measured in several ways as previously mentioned. First, a sufficient number of all hatchery fish (targeting 100%) will be otolith marked. Next, a sufficient number of fed fry and/or fingerlings released over a size of 0.5 gram will be adipose clipped. We estimate that more than 85% of the images of adult returns recorded by the camera/video system at the weir were clear enough to determine the presence or absence of adipose clips in 1999. This large number of fish monitored can be done non-obtrusively as a standard part of the monitoring program to determine the proportion of the total run that is comprised of hatchery fish. Next, otoliths will be recovered and read from as many brood stock collected and spawn outs and carcasses recovered as necessary, in addition to adult fin clips observed by camera and by spawner surveyors, to accurately determine stock components and stray rates in all spawning areas. Saprolegnia infections are prevalent on the top portion of most adipose fins of adult spawners which makes it difficult to tell whether some fins were partially clipped or just covered by fungus. This problem makes it necessary to rely primarily on otoliths for more precise determinations which can be confirmed by fin clips at the weir and in pre- and post-spawning adult returns. Since the program relies in part on egg and unfed fry releases, fin clips will not always be possible.

In 1994, 10,570 left-ventral-clipped fed fry of a total release of 44,411 fed fry (23.8% of the release were fin-clipped) were released immediately offshore of the major spawning beaches in Lake Ozette. The beach spawner surveys conducted in 1998 found only 2/165 beach spawners sampled from the beaches that were left-ventral-clipped (1.21%). An expansion for unmarked fish suggests that approximately five percent of the beach spawners in 1998 were of first generation hatchery origin from this nearby lake fry plant. The majority of the returning hatchery origin adults returned to Umbrella Creek where early imprinting on the hatchery water source influenced their return. The incidence of hatchery-origin adults on Olsen's Beach was low even when fry were released directly onto the beaches, which has been discontinued. Ventral fin clipping has been discontinued.

In 1995, 24.9% of the release of 45,220 fed fry into Umbrella Creek from brood year 1995 were adipose clipped yet out of 121 adults captured from Olsen's Beach in 1999, none were adipose clipped. This demonstrates that straying from tributary plants to spawning beaches was nonexistent or very low when fry were reared and released directly into Umbrella Creek.

10.4.6) Gene flow from program fish into natural populations:

To monitor hybridization and gene flow among all spawning aggregations of *O. nerka* within the basin, if any occurs, MFM and NWIFC have procured preliminary funding (Attachment 2; Section 12) to develop profiles from 6-8 microsatellite DNA loci from *O. nerka* spawning aggregations within the Ozette Basin. The NMFS offered to provide existing allozyme genetic data or samples when possible of Lake Ozette sockeye beach spawners to complement ongoing genetic research, which will help to characterize baseline genetic profiles of sockeye and kokanee spawning aggregations necessary for future monitoring.

Monitoring Origin and Identity of Brood Stock:

All spawning aggregations have been identified and can be individually retained based on their geographic separation and the separate capture, transport, holding, spawning, and rearing methods previously discussed. The potential that the two known spawning beaches represent two unique and distinct suppopulations is being determined. Genetic sampling will allow us to determine differentiation between beach aggregations and among brood-years.

To representatively sample the wild beach aggregations, we will continue to collect fin tissue samples from carcasses supplemented with samples non-lethally taken from live fish targeting spawn outs for genetic analyses of population structure, as described in Attachment 2. Sampling of spawners will be reduced to the number necessary (if any) to complement samples taken from carcasses or spawn outs to minimize adverse impacts to natural spawners. A sufficient number of hatchery fish, beginning with brood year 1999, will be differentially otolith marked to identify release site, strategy, and hatchery origin. Otolith and fin clip ratios in brood stock will confirm the identity of the donor spawning aggregations. All brood stock as well as fish captured, but not retained for brood stock, will be non-lethally, fin-clip sampled (top 1 cm lobe of caudal fin). Fin tissue will be retained in 100% ethanol until analyzed using DNA techniques. At the time of spawning, brood stock will be sampled in duplicate for muscle, eye, heart, liver, and fin tissue, as will any other mortalities found in the field in suitable condition or those mortalities that may occur during brood collection or holding. One set of these samples will be held in an ultra-cold freezer and the other will be placed directly into ethanol until analyzed as previously described.

Monitoring efforts will determine sex ratios of all adult sockeye captured. Genetic samples will be collected from as many adult brood stock and carcasses as necessary for accurate determinations.

Sufficient marking (targeting 100%) will be employed to distinguish between hatchery and natural origin fish and to precisely estimate the proportions of wild and hatchery returns in the lake and tributaries. By including a known number of fin-clipped, otolith-marked, fed fry or fingerlings with each release, the contribution of hatchery fish and therefore wild fish, can first be observed in 85% of the annual run size entering the lake by video camera. Survival of fin clipped adults originating from fed fry and/or fingerling releases compared to survival of other release strategies can be determined by reading otoliths, using the fin clips as quality control of the otolith reading procedure. Using fin clip marking, otolith marking, and genetic analysis of future returns, we will evaluate abundance and trends in abundance of hatchery and wild spawners. Accurate wild to hatchery ratios will be recorded and monitored annually. This information will be used as the quantitative basis for revising methods as necessary through adaptive management.

Annual monitoring methods will assist in determining stray rates. We will estimate the proportion of the total run size comprised of hatchery and wild lineage, using video camera as previously described. We will determine the lineage of all brood stock collected from Umbrella Creek using sufficient otolith marking to enable monitoring and evaluation, and quality control of the otolith identification methods will be performed by comparing the otolith results to known hatchery origin fish that are adipose clipped. Otoliths can be extracted and fin clip incidence will be determined from carcasses recovered annually to determine wild/hatchery ratios.

The proportion of hatchery and wild adults spawning on each beach can be estimated using incidence of fin clips and otoliths collected from non-lethal and lethal sampling of adults in 2000/2001 and 2001/2002 for limiting factors studies and when collecting genetic samples. The lineage of adults spawning on each beach can be estimated in the future using incidence of fin clips and otoliths collected in a sufficient number of all brood stock and carcasses recovered.

Wild spawning areas in tributaries and in the lake will be surveyed adequately to accurately determine wild to hatchery ratios. Spawner abundance and distribution of hatchery and NOR returns will be monitored in Big River and Umbrella Creek. Spawner densities will be determined, and locations of preferred areas mapped. Annual, generational, and long-term changes in spawning distribution will be determined for all spawning aggregations of Ozette sockeye, and comparisons made between hatchery and wild fish. Hydroacoustic surveys and sonic/radiotagging studies are proposed for 2000/2001 and 2001/2002 to study holding, distribution, spawning behavior, measure abundance before and during spawning, and to determine adult survival from lake entry to spawning in all currently known, as well as in currently unknown, areas within the lake.

Pinniped predation of adult sockeye in the lake and river will be monitored annually by camera and visual observers. Scarring rates will be monitored by camera and during tag and recapture experiments (such as in Attachment 1) to estimate overall mortality of adults due to pinniped predation.

Monitoring Brood Stock Collection:

To ensure that brood stock collection methods are unbiased, an annual, multi-trait database including age, sex, length, weight, fecundity and mean egg diameter will be kept for brood stock collected. Fecundity will be determined from pooled eggs from each egg take. This database will be examined for trends annually to prevent or detect any selectivity in capture and culture methods, and/or phenotypic changes that may affect long term fitness of target wild spawning aggregations.

Capture and transfer procedures will be monitored to insure acceptable mortality and injury rates. Any mortality, injury, or other observations of fish health will be documented. The cause of any mortality will be determined and addressed immediately through adaptive management to reduce the possibility of any future losses that can be prevented.

Maintenance of disinfected tanks, equipment, and adequacy of oxygen systems of transport vehicles and vessels will be monitored. Brood stock held in covered, circular, holding tanks at the Umbrella Creek Hatchery will be segregated by origin of capture, and their health and spawning condition will be monitored daily and every three days, respectively. If necessary, monitoring health and operation of hatchery systems can be increased to twice daily when brood stock are held on hatchery premises. An itemized description of equipment and associated costs has recently been developed by MFM, and funding is being sought, to acquire backup oxygen and satellite telephone alarm systems connected to a float switch on the inflow line at the Umbrella Creek Hatchery.

Monitoring of Mating:

All ripe brood stock on any spawn date will be assigned random numbers, randomly selected, and the resulting spawning matrices will include only individuals from the same spawning aggregation. Gametes from each parent will be number-coded and recorded for parents contributing to each correspondingly numbered spawning matrix. All spawning crosses will be entered into data collection sheets daily, which will be entered onto computer spreadsheets and submitted to MFM from the hatchery weekly and subsequently monitored. All adult gametes will be monitored for the incidence of infectious fish pathogens. The numbered crosses will then be identified as to their pathogen status, origin, and family composition.

Monitoring of Rearing:

Embryo development will be monitored throughout the incubation period and temperature data, hatching, and emergence times will be projected before and after eggs reach the eyed stage as well as recording actual emergence times observed in the hatchery annually. Survival rates from green egg to swim-up and from swim-up to release will be monitored and compared to the average hatchery rates. Both rates are expected to remain above the overall mean rates.

We will allow for and monitor volitional swim up. Survival and health of eggs, swim up fry, and fed fry will be monitored throughout the rearing period by MFM in conjunction with a pathologist from the NWIFC Fish Health Laboratory in 1999. Beginning in 2001, parental pathogen status and egg health will be monitored by the disease subpanel when eggs are incubated at MNFH. Fry will continue to be monitored by the NWIFC pathologist at the Umbrella Creek Hatchery in conjunction with MFM. Segregation of spawning aggregations will be monitored and maintained.

The daily feed ration will be monitored and presented to fry continuously to mimic the daytime lacustrine continuous feeding behavior of sockeye fry. Human contact with fry during feeding and cleaning will be monitored and held to a minimum to reduce conditioning and subsequent vulnerability to predation. Daily monitoring, or more frequent monitoring during freshets, will be conducted to ensure that the 20-foot well screen located in the impoundment pool remains clean during fry rearing. As previously mentioned, MFM is in the process of securing backup oxygen and alarm systems at the Umbrella Creek Hatchery.

Monitoring Release:

Eyed egg aliquots from each spawning matrix that will be destined for each release strategy will receive a unique otolith mark for monitoring postrelease survival. Annual monitoring and archiving of differential otolith marking patterns for each group will be held on file for future identification of wild fish at the WDFW Otolith Laboratoy in Olympia, Washington.

Upon release, this project will monitor and record life stage, location, date and time, size, and number released. The rearing method will be identified by differentially marking all eggs, fry, and fingerlings to distinguish procedure employed. Adult demographic characteristics measured during spawning ground surveys, including fin clip incidence and otolith marks present in carcasses and brood stock, will be used to monitor and evaluate effectiveness of the releases. This will also allow a comparison of the relative contribution of hatchery and wild spawning aggregations in distinct areas and in the overall population.

In addition, changes in genotypic, phenotypic, ecological, and behavioral characteristics of all spawning aggregations will be monitored. Based on this demographic information and biological criteria, effectiveness will be evaluated to determine if program changes are needed, if certain programs should be discontinued, or when a program has accomplished it's goals and is no longer necessary.

Numbers of hatchery and NOR returning adults resulting from eyed egg reintroduction releases can be readily monitored in tributaries or on lake beaches to Lake Ozette where sockeye no longer exist because all *O. nerka* detected in these areas will have originated from the reintroduction plants.

The number of unmarked, lake-origin returns passing the weir will be monitored as follows. First, total numbers of externally marked/clipped and unclipped adults will be determined annually at the weir by camera and/or by visual observers. Following spawner surveys in the tributaries, numbers of clipped and unclipped adults will be determined. The total numbers of unmarked tributary returns counted in spawner surveys can then be subtracted from the weir counts to reconstruct the run size of unmarked, lake-origin adult returns. Once all of the otoliths in brood stock and carcasses are read and fin clips are physically counted and expanded, the relative survival of clipped fingerlings to unmarked eggs, unmarked fry, and NORs can be compared annually. These relative survival rates among different release strategies/stages of marked and unmarked hatchery fish and relative spawner replacement rates among natural and hatchery returns can be compared to the actual numbers enumerated and eventually used to predict/forecast returns of these various stock components at the weir for each spawning aggregation.

A more difficult task will be to monitor reproductive success of lake spawners. Based upon the lake holding survival of adults observed in the ongoing sonic tagging experiments, complemented by hydroacoustic enumeration of spawners, snorkel and scuba spawner and redd surveys (employing a redd disturbance area method to estimate the true number of redds to compensate for mass spawning), realistic estimates of pre-spawning mortality can be applied to the run size of lake-origin fish to determine the number of lake returns that survive to spawn. Predation estimates will be very important in this calculation. If a significant number of adults can be sonically tagged and tracked in the 2001 return (such as 10% of the return), their survival should be a robust estimate of pre-spawning mortality (including seal predation). This number can then be compared to the number of spawners enumerated by hydroacoustic, scuba, and snorkel surveys, as well as to the number of spawners estimated from redd disturbance area, to begin to get a handle on the number of adult sockeye that spawn on various beaches. Although this will be difficult to do, we believe that the great improvements that have recently been made in estimating run size at the weir by employing the underwater camera technique, give us far more accurate abundance estimates than existed previously. While estimates of individual spawning aggregation abundance are more difficult, we believe that the overall estimates of lake and tributary abundance, determined as described in the previous paragraph, will be very accurate; certainly far more accurate than past estimates.

The health status of each egg release group and parent gamete pathogen status will be monitored prior to eyed egg releases to ensure that health and likelihood for survival is high.

General temperature profiles of release areas will be monitored annually by planting thermographs at all spawning, incubation, and release sites, with particular attention initially given to monitoring temperature near upwelling seeps and near natural redds above and below gravel on the lake beaches (1998 to 2000). Thermal profiles at all locations will be compared among spawning times for all spawning aggregations. In 1999/2000, MFM planted thermographs above and below gravel on each lake beach in sites where later, numerous redds were constructed. Also, these thermographs canvassed each beach spawning area in the lake including sites with and without springs. These thermographs remain in the lake at the time of this writing. Hatching and emergence will be projected at the release sites based upon temperature unit requirements for Lake Ozette sockeye (Section 8.4; Table 11) and by direct observation of hatching and emergence rates in the hatchery. Temperature profiles will be archived along with samples of each otolith mark group annually and used to assist with interpretation of otolith banding patterns later in the adult returns.

Survival rates for eyed eggs used for reintroduction will be determined by collection of shells and unhatched eggs from lake and in-stream incubators and RSI's. In 1999, survival rates of eggs (from brood year 1998) in Jordan incubators were measured on Olsen's Beach, in tributary environments, and in hatchery tanks under a controlled setting. A total of 18 incubators were loaded with 2, 3, and 4 eyed eggs per cell on February 20 and 26, 1999, and anchored above substrate in approximately 12 feet of water on Olsen's Beach. Of a total of 10,593 eyed eggs, 10,593 (97.3%) were estimated to have hatched (97.3% ±

0.54% ; range 92.5% - 99.5%). Survival rates of eggs held in the lake at the three different loading densities in egg incubators were compared by 1-Factor Analysis of Variance (ANOVA) and were found to not be significantly different ($p>0.10$). Since there were two egg takes and three positions that incubators were housed within blocks, survival was compared among egg takes and incubator positions by ANOVA and was not found to be significantly different among egg takes ($p = 0.7243$) nor among incubator positions ($p = 0.4969$). Egg survival in Crooked Creek was evaluated at 12 different sites in a total of 44 incubators at two eggs per cell. Survival varied extensively among the sites due to several incubators that were placed in habitats more prone to high flows which resulted in scouring which unearthed the top portions above the gravel or which deposited excessive fine sediment on top of some of these incubators. Of a total of 27,337 eyed eggs planted, 20,273 were estimated to have survived (74.2%; range 0.78% to 100%). Of 28,752 eyed eggs held in 48 incubators at three eggs per cell (47 @ 600 per incubator; one at 552) under a controlled setting in hatchery tanks at Umbrella Creek Hatchery, 28,473 successfully hatched (99.02% ± 0.09%; range 96.5% - 99.8%).

Based on findings in 1999, more suitable egg incubator planting sites were located in Big River by MFM in 2000 (to plant eggs from brood year 1999) and survival was again measured in Jordan incubators buried in substrate in this tributary. Survival was also measured in lake incubators anchored above gravel and an artificial substrate housed inside anti-predator cages on Olsen's Beach in 2000. Of a total of 17,575 eggs planted in 44 incubators in Big River in 2000 (2 eggs per cell; 400 per incubator), 17,299 (98.4%) were estimated to have successfully hatched. Among nine planting locations, the grand mean was 98.3% ± 0.008%. As noted by the SEM, results were consistent with only three incubators having survival below 98%. Also in 2000, a total of 42 incubators were also seeded with two eggs per cell (400 total per incubator) and anchored on Olsen's Beach as described above in this paragraph. Of a total of 17,310 eyed eggs planted in the lake, survival averaged 96.1% ± 0.006%; ranging from 88.8% to 100%. Survival rates compared by ANOVA among three positions within blocks housing the incubators were not significantly different ($p>0.10$) in Big River nor in the lake.

Fry emergence will be monitored on an "as needed to know" basis using fyke nets placed near tributary outlets to estimate productivity and emergence timing of wild and hatchery tributary fry. Future estimates of reproductive success (fry per spawner) can be produced from comparisons of the relative contribution of NOR and hatchery spawners to outmigrants, determined by spawner surveys and collecting cohort fry otoliths from fyke net mortalities. Tissue samples may also be taken from fry mortalities to examine and compare the genetic composition among wild and hatchery fish; however, actual monitoring of genetic composition will focus on the natural beach spawning aggregations annually using DNA analysis of non-lethally collected fin tissues and additional tissues collected from any spawners and carcasses as necessary to complement the sample size. Fyke netting of NOR sockeye and coho fry in Umbrella Creek in 1999 was illustrated in Figures 16 and 17. Fyke netting of outmigrating hatchery fingerlings was also accomplished from June through October of 1999 in Umbrella Creek (Figure 25).

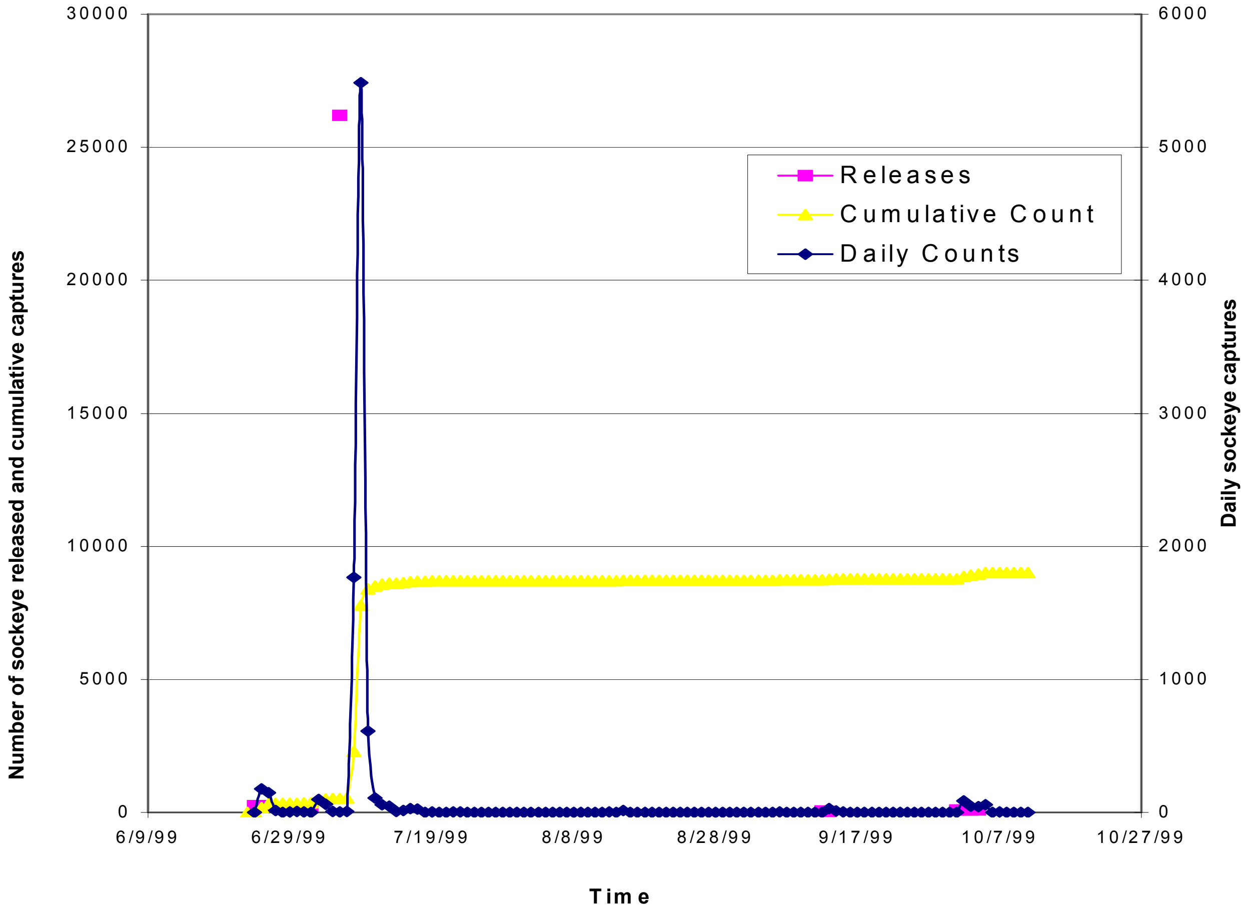

Figure 25. Hatchery sockeye fingerling releases in Umbrella Creek (RM 4.5), cumulative and daily fyke net outmigrant captures at RM 1 from June to September, 1999.

In 1999, MFM funded a study in collaboration with the WDFW Otolith Laboratory in Olympia, Washington, to examine natural otolith banding patterns resulting from eyed eggs incubated in lake and tributary water to see if a natural "riverprint" could be detected in river spawners. Replicated incubators were weighted to the lake bottom on each beach housed within nylon bags to collect emerging alevins. The incubators were placed adjacent to a series of thermographs which measured subgravel, above gravel, and within water column water temperatures in the lake. Future monitoring may not include this degree of temperature monitoring once temperature profiles have been determined for the planting areas.

At the same time, eyed eggs from the same egg take were also incubated until hatching at the Umbrella Creek Hatchery, which is supplied by water from the tributary to Umbrella Creek at RM 4.5, to compare natural banding patterns of newly hatched fry of known incubation locations of lake - and tributary -origin upon emergence. In addition, eyed eggs were pumped from natural sockeye redds in Umbrella Creek and held at the Umbrella Creek Hatchery until hatching when they were euthanized for otolith analysis. Upon emergence, ten alevins from each of the treatments (lake, hatchery, and Umbrella Creek NOR's) were sacrificed and their otoliths were compared.

Otoliths originating in fry incubated on both lake beaches were distinguishable from otoliths of natural origin recruits hatched from sockeye eggs pumped from gravel in Umbrella Creek and from eggs of lake origin that were incubated at the Umbrella Creek Hatchery; but eggs incubated on Allen's and Olsen's Beaches were not distinguishable from one another as postulated.

Upon examining river - and lake - origin otoliths in emergent fry, adult returns to Olsen's Beach (lake) and Umbrella Creek (tributary) were compared (blind analysis) to see if examiners could distinguish signature banding patterns, for lake or tributary origin, in their otoliths. A total of only three adults were examined for otolith banding patterns from Umbrella Creek but a total of 95 adults were sampled from Olsen's Beach. The proportion of spawning adults originating from the Umbrella Creek Hatchery on Olsen's Beach in 1999 was estimated to be approximately 5%. This high proportion of adults from the hatchery were not strays but rather, they were expected because fingerlings were planted off of Olsen's Beach. Regardless, since approximately 5% could be expected to be of hatchery origin, 95% could be expected to be of wild, beach origin (90 adults in this sample). Blind reading of results indicated that 3/3 (100%) of the fish from Umbrella Creek were correctly identified as tributary origin fish. Of the beach spawners, 83.2% were identified to be of lake origin, 14.7% were identified to be of tributary origin, and 2.1% were unknown. The percentage of the 95 fish sample from Olsen's Beach determined to be of lake origin by otolith analysis (83.2%) was close to the expected percentage of beach spawners (95%), being off by 11.8%.

This analysis is important because it demonstrates that fish of tributary or of lake origin can be identified, with a fair amount of precision, on years when no otolith marking occurred or in natural spawning aggregations that are not subject to otolith marking. Gao and Beamish (1999) demonstrated that stable isotopic composition of otoliths can be used as a chemical tracer to discriminate stocks and migration patterns, if there are indicative isotopic differences among different water masses or habitats. Nelson *et al*. (1989) compared the δ^{18} O value of otoliths in common smelt (*Retropinna retropinna*) with that of their freshwater habitat, and concluded that there is a potential to use stable isotopes, in both δ^{18} and δ^{18}, to distinguish smelt by their habitat waters.

Therefore, we may be able to distinguish a chemical tool for discrimination of spawning aggregations of Lake Ozette sockeye if there are distinct physical and biological differences among lake beach and tributary incubation environments. In particular, we are interested in knowing the isotopic values and variation ranges of sockeye in their different spawning habitats within the Basin to establish isotopic standards. If successful, the chemical tool or tracer may provide a low cost and more effective alternative to DNA analysis to not only identify spawning aggregations of Lake Ozette sockeye but also, this technique may be applicable to identify stocks of salmon or groundfish in other mixed stock fisheries, etc. This technique may be useful for monitoring hatchery returns in 200 through 2002 because no otolith marking was accomplished in their corresponding cohort release years (1996 through 1998). This method may also be useful to identify the origin of unmarked NOR fry, to provide an alternate method in addition to thermal marking, and to provide quality assurance and control of thermal marking results. Finally, once release strategies are fixed, and presuming that this new method proves to be accurate, it may allow for monitoring of the different spawning aggregations without requiring any handling or mass marking.

The isotopic technique has been rarely used in stock identifications and has never been used in such closely related spawning aggregations. Thus, the proposed project may provide the first definitive information about the environmental conditions during early life history of spawning aggregations of Lake Ozette sockeye. Variations in temperature as well as in water chemistry among different incubation environments are reflected in stable isotope concentrations of otoliths in the primordial core of the otolith. Despite this work to identify fish origins from natural, non-thermally marked otoliths, the intention of this HGMP remains to differentially otolith thermal mark a sufficient number of all program fish targeting 100%.

We propose to collect representative sub-samples of fry before release to assess health, and otolith marking efficiency, and to measure survival to eyeing, hatching, and emergence. It will also be important to monitor the incidence of infectious fish pathogens in fry outmigrants. All fry exhibiting clinical disease will be retained at and sent to the NWIFC pathologist.

Fry releases will be monitored to mimic natural migrational characteristics of sockeye salmon fry in Umbrella Creek including release location and time of release. Swim up fry release dates and times will be monitored to ensure that they are concurrent with the same date and time period when fry from naturally produced salmonid aggregations in tributaries emigrate to lacustrine habitats to initiate feeding. This will fall within the emergence period of lake origin fry as described in Sections 3 and 8.4. Fry emigration behavior will be studied on those years when fyke netting is deemed necessary to compare migratory patterns and record egression time. Timing of springtime plankton blooms should be studied annually to optimize release timing of fed fry. Size of fed fry or fingerlings will approximate the normal size range of natural lake fry. Size at release will be monitored to maximize postrelease survival while minimizing adverse ecological interactions with wild Lake Ozette sockeye, minimize adverse environmental conditions (such as low flows), and to minimize adverse effects on behavior (such as disposition to migrate) that may be associated with later releases of larger fish.

Piscine predation of eggs and emergent sockeye fry on lake beaches and in proximity to tributary outlets where sockeye have been introduced will be monitored, on an as need to know basis, using beach seines.

Smolt outmigration will be monitored using a screw trap to estimate total freshwater and saltwater productivity of natural and hatchery origin fish. Getting support for funding from NMFS and cooperation from ONP to install the screw trap in the Ozette River will be extremely valuable to enable future assessment of total freshwater NOR and hatchery abundance and productivity as well as marine survival of each stock component. As with fry fyke net sampling, numerous genetic, behavioral, ecological, and demographic data can be collected from differentially-marked and clipped smolts resulting from each release location and life history stage released, separately and collectively.

As previously described, natural and hatchery origin adult sockeye abundance will be monitored annually through weir counts and tributary and lake spawner surveys. Ongoing sonic tagging and hydroacoustic studies will allow for estimation of lake holding mortality. Redd surface area measurements will be used to estimate reproductive success on lake beaches where mass spawning takes place (some "redds" on lake beaches were in excess of several hundred square meters).

10.5) Unknowns or uncertainties identified in Sections 5 through 9:

N/A

10.6) Other relevant monitoring projects:

See the following Section 11 (Research) and Attachments 1-3 in Section 12 for detailed proposals for some select monitoring projects.

SECTION 11. RESEARCH

(Note: This section is being reviewed against Section 10 requirements and will be edited as needed.)

Provide the following information for any research programs conducted in association with the HGMP. Correlate with research described in any ESU hatchery plan approved by the co-managers and NMFS.

Project Titles:

- Lake Ozette Sockeye Salmon Predation Assessment and Survey Research Study (Attachment 1)
- Ozette weir returning adult enumeration, predation, run timing, tagging, and proportion of hatchery to wild returns.
- Egg survival studies: Egg baskets and incubators.
- Fry enumeration studies: Fyke netting.
- Egg and emergent fry predation studies: Fyke netting, beach seining, snorkel surveys.
- Freshwater and saltwater productivity and survival rates, smolt enumeration: Smolt screw trap.
- Habitat surveys.
- Tributary and lake spawner surveys.
- Beach habitat characterization, mapping, and spawner utilization.

11.1) Objective or purpose:

Need for data; benefit or effect on wild population; broad significance of project.

Little is known about the mortality rates of Lake Ozette sockeye at any life stage. Abundance of the species has been poorly documented in the past. Previous methods used to assess adult abundance have been shown to underestimate the number of adults by an order of magnitude (MFM unpublished data). The above research programs are designed to answer the following questions about abundance, spatial and temporal distribution, habitat condition and utilization, and life stage mortality patterns:

- What is the current adult abundance and what is the population trend for each brood year?
- What are in-season trends or changes in adult abundance and distribution?
- What are the survival rates at different life stages?
- What factors are affecting survival during freshwater and saltwater life history stages?
- What is the current and potential capacity of Lake Ozette and its tributaries for sockeye production?

The answers to these questions are crucial to understanding the population dynamics of Lake Ozette sockeye. Without the information that these research programs will provide, it will be impossible to determine how many fish there are, how many there should be, what life stages are being inordinately impacted, or how to recover the population.

11.2) Cooperating and funding agencies:

Predation studies will be conducted by the Makah Tribe in cooperation with NMFS NMML personnel, based out of the Alaska Fisheries Science Center, Seattle, Washington. Makah Fisheries Management and J.C. Headwaters, Ontario, Canada, will conduct radio/acoustic tagging, tracking, and hydroacoustic surveys of adult spawners in 2000/2001 and 2001/2002. Other work will be conducted by the Makah Tribe and other agencies to be determined.

11.3) Principal investigator or project supervisor and staff:

Makah Fisheries Management will be the principal investigator in the Lake Ozette Sockeye Salmon Predation Assessment and Survey Research Study. Pat Gearin, NMML-NMFS will consult and participate in marine mammal predation studies with MFM. Dr. Chad Gubala, President of J.C. Headwaters, Inc., and Hap Leon of North Coast Resource Management will consult with Makah Fisheries Management to implement radio/acoustic tagging, tracking, and hydroacoustic surveys. The principle investigator for other work will be MFM staff and others to be determined.

11.4) Status of stock, particularly the group affected by project:

The Lake Ozette sockeye ESU was formally listed by NMFS as a threatened species on March 25, 1999.

11.5) Techniques: include capture methods, drugs, samples collected, tags applied:

Table 19. Capture methods for proposed future research projects.

Study Description	Capture Methods	Drugs	Samples Collected	Tags Applied
Lake Ozette Sockeye Salmon Predation Assessment and Survey Research Study	Weir traps (Attachment 1; Biological Opinion)	MS-222 @ 50-100ppm, clove oil @ 30 to 60 ppm	(Attachment 1; Biological Opinion)	Floy tags, combined sonic/radio tags
Ozette weir adult enumeration and proportion of hatchery to wild	N/A, fish diverted through counting weir	N/A	N/A, passive determination of hatchery/wild abundances	N/A
Egg Survival	See brood stock capture method	N/A	N/A	N/A
Egg and fry predation on lake beaches	Beach seine	N/A	Morts (stomach, genetic, otolith, disease analyses)	N/A
Fry Enumeration	Fyke net	N/A	N/A	N/A
Emergent Fry Predation	Fyke net, beach seine	N/A	Morts (genetic analysis)	N/A
FW & SW Survival & Smolt Enumeration	Smolt Trap	N/A	Morts (genetic, otolith, disease analysis)	N/A
Habitat Surveys	N/A	N/A	N/A	N/A
Spawner Surveys	N/A	N/A	Morts (genetic, otolith, disease analysis)	N/A

11.6) Dates or time period in which research activity occurs:

Table 20. Timeline for proposed research projects.

	J F M A M J J A S O N D
Lake Ozette Sockeye Salmon Predation Assessment and Survey Research Study 2000/2001	-----------------| |---|
Ozette Weir Adult Monitoring	|----------------------------------|
Sonic/Radio Tagging and hydroacoustic survey 2001/2002	------------------| |---
Egg Survival	-----------------------------| |--------------
Egg and fry predation on lake beaches	------------------------------------| |--------------
Fry Enumeration	|--------------|
Emergent Fry Predation	|--------------|
FW & SW Survival & Smolt Enumeration	|-----------------------|
Habitat Surveys	|--|
Spawner Surveys	--------------| |--------

11.7) Care and maintenance of live fish or eggs, holding duration, transport methods:

For the Lake Ozette sockeye predation assessment survey research studies in 2000/2001 and 2001/2002, adult sockeye will be captured at lower and upper Ozette River sites, anesthetized, photographed, sampled, and tagged as described in the NMFS Biological Opinion (Attachment 1).

Fry and smolts will be captured while conducting the following research programs: fry enumeration, emergent fry predation, fry-to-smolt survival, and smolt enumeration. These fish will be held only long enough to count them. Adult traps will be monitored 24 hours per day when in operation, and fry traps will be checked at least daily. When conditions warrant, traps will be checked more often to minimize stress on the fish due to excessive densities or other unfavorable environmental conditions. Fish will be counted from the traps into buckets and released immediately downstream in the case of fyke netting studies and in smolt trapping programs. Buckets will be emptied frequently and refilled with clean water to minimize stress and potential for disease transmission. During the emergent fry predation study, beach-seined sockeye fry and smolts, if present, will be released immediately upon identification.

Eggs from brood stock collected for supplementation will be used for egg survival research programs. Methods and handling for egg collection from brood stock can be found in Section 7 (Mating), and Section 8 (Incubation and Rearing).

No other programs which require handling of live fish or eggs have been identified at this time that were not previously described in this HGMP.

11.8) Level of take: Number or range of fish handled, injured, or killed by sex, age, or size:

See Table 21.

11.9) Potential for/estimates of injury or mortality, and methods to reduce either:

See Table 21.

11.10) Alternative methods to achieve project objectives:

See Table 21.

11.11) List species similar or related to the threatened species; provide number and causes of mortality related to this research project:

See Table 21.

Table 21. Estimated take of listed and related species from proposed research projects.

Study Description	No. Handled	No. Injured (estimate)	No. Mortalities (estimate)	Description (sex, age, size, etc.)	Methods to Reduce Injury/Mortality	Alternate Methods	Other Species Affected
Lake Ozette Sockeye Salmon Predation Assessment and Survey Research Study 2000/2001	115 (See Section 12 Attachment 1)	11 (See Section 12 Attachment 1)	6 (See Section 12 Attachment 1)	6 adults	Minimize handling, use anesthetic, cotton gloves, sterile technique	N/A	N/A, possibly 2 or 3 adult steelhead kelts
Ozette Weir Adult Monitoring	0	0	0	Entire run	Leave weir open at all times	N/A	N/A, possibly adult steelhead kelts
Sonic/Radio Tagging and hydroacoustic survey 2001/2002	200	20	10	10 adults	Minimize handling, use anesthetic, cotton gloves, sterile technique	N/A	N/A, possibly 2 or 3 adult steelhead kelts
Egg Survival	3,000-6,000 eggs	0	2	2 adults	N/A	N/A	N/A
Egg and fry predation assessment on lake beaches	No eggs handled, up to 1,000 fry	20	20	60% male, 40% female, swim up fry	N/A	N/A	N/A
Fry Enumeration in Umbrella Creek	10,000	400	300	60% male, 40% female, swim up fry	Check trap at minimum daily, limit fyke netting	N/A	Coho, steelhead swim up fry
Emergent Fry Predation	0	0	0	0	N/A	N/A	Sculpin
FW & SW Survival & Smolt Enumeration	5,000	250	150	60% male, 40% female, smolts	Check trap daily, trap only 10 % with screw trap, limit smolt trapping	N/A	Coho, steelhead
Habitat Surveys	0	0	0	N/A	N/A	N/A	N/A
Spawner Surveys	0	0	0	N/A	N/A	N/A	N/A

Fish handled for fry enumeration are the same fish handled for the predation study; sculpin are necropsied.

SECTION 12. ATTACHMENTS AND CITATIONS

Attach or cite (where commonly available) relevant reports that describe the hatchery operation and impacts on the listed species or its critical habitat. Include any EISs, EAs, Biological Assessments, or other analysis or plans that provide pertinent background information to facilitate evaluation of the HGMP.

This HGMP is the biological assessment for supplementation and reintroduction, biological monitoring, and research of Lake Ozette sockeye salmon. This plan is presented here also as part of the Tribal Resource Management Plan and Lake Ozette Sockeye Recovery Plan for 4(d) exemption from take under the ESA. The NMFS biological opinion for the predation assessment, radio/acoustic tagging, tracking, and hydroacoustic surveys is attached below (Attachment 1). See Literature Cited below the attachments in this section for pertinent background information. Research methods additional to Section 11 are described below:

Attachment 1. Biological Opinion. Ozette Lake Sockeye Salmon Predation Assessment and Survey Study.

File Index Code: 8.6.3

Endangered Species Act
Section 7 Consultation

BIOLOGICAL OPINION

Ozette Lake Sockeye Salmon Predation Assessment and Survey Research Study

Agencies: Bureau of Indian Affairs (Makah Indian Tribe - lead agency)
National Marine Fisheries Service Marine Mammal Lab (co-operator)

Consultation Conducted by: National Marine Fisheries Service, Northwest Region

Date Issued:

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Background

The Makah Tribe is a federally recognized treaty tribe with usual and accustomed fishing areas under its jurisdiction including the Ozette River Basin, located on the northwest corner of the Olympic Peninsula in Washington state. Missions of the tribe include conserving salmonid populations in regional waters and recovering depressed populations to self-sustaining, harvestable levels. The Tribe, in cooperation with the National Park Service, the National Marine Fisheries Service (NMFS), the Quileute Tribe, and the Washington Department of Fish and Wildlife (WDFW), has determined that recovery of Ozette Lake sockeye salmon (*Oncorhynchus nerka*) depends upon implementation of effective management actions that will address limiting factors responsible for the population's decline. Potential limiting factors include: marine mammal, fish, and bird predation and disruption of natural predator–prey relationships; loss of spawning habitat and productivity, introduction of non–native fish and plant species; past over-exploitation (there have been no directed harvests for the past 16 years); poor ocean conditions; and the interactions of these factors. To identify the effects of marine mammal predation on Ozette Lake sockeye salmon, the Makah Tribe, in cooperation with the NMFS Marine Mammal Lab (MML), proposes to assess sockeye salmon predator scarring rates. A survey of interactions between river otters (*Lutra canadensis*) and harbor seals (*Phoca vitulina*), and migrating and spawning sockeye salmon is also proposed, including predation observations and identification of areas of co-occurrence. In conjunction with the harbor seal and river otter predation study, the Makah Tribe also proposes to tag adult sockeye salmon with combined acoustic and radio transmitter tags as a pilot study. This pilot study will include development of a team to procure and test the equipment and methods needed to track adult sockeye salmon distribution and relative abundance in Ozette Lake and its tributaries in 2000. Based on the success of these methods, an expanded tagging and hydroacoustic survey of a representative portion of the 2001 return is planned. The tagging projects will collect valuable baseline information that is presently lacking regarding sockeye salmon spawning distribution, abundance, spawning habitat utilization, and reproductive success in Ozette Lake. Findings from both portions of the proposed study will improve scientific understanding regarding the extent of river otter and harbor seal predation effects on the status of Ozette Lake sockeye salmon, and on the basic life history elements of the listed population from which initiatives to address limiting factors can be formed.

I. Description of the proposed actions.

A. Harbor Seal and River Otter Predation Assessment .

The objectives of the proposed predation assessment research program are to identify the effects of river otter and harbor seal predation on sockeye salmon productivity. Specific objectives pertaining to predation research include: collection of more accurate predator scarring rate data on returning adult sockeye salmon in the Ozette River; determination of the locations in the river where predator scarring is occurring and by which predators; determination of the severity of the predator scars on sockeye salmon with regard to whether increased mortality could result; assessment of the abundance of river otters and harbor seals in the Ozette River; determination through surveys of the distribution and abundance of harbor seals and river otters in Ozette Lake, especially in proximity to known spawning sites; determination though intensive surveys at known sockeye salmon spawning sites in Ozette Lake of the occurrence of harbor seals and potential predation rates on sockeye salmon during the spawning season; collection of data though intensive day and night surveys in the vicinity of the sockeye salmon weir in the upper

Ozette River to identify river otter and harbor seal interactions with migrating sockeye salmon; and determination of the number of individual otters and seals preying on sockeye salmon (Makah and NMFS 2000).

To effect the harbor seal and river otter predation assessment, the Makah Tribe also proposes to capture, handle, sample, and release adult sockeye salmon at two locations in the Ozette River. The Makah Tribe and NMFS also propose to monitor seal and otter occurrence and behavior via foot and boat surveys in the Ozette River and on Ozette Lake through the sockeye salmon migration and spawning season. The seal and river otter occurrence and behavior surveys are not expected to take listed sockeye salmon. The focus of this Opinion pertaining predation assessment, including the description of proposed actions, will therefore be directed toward those portions of the study that involve the capture, handling, sampling, tagging, and release of listed sockeye salmon.

1. *Proposed sockeye salmon capture actions in the lower Ozette River.*
To initiate the predation study, the Makah Tribe proposes to capture up to 115 sockeye salmon adults in the lower Ozette River for examination and tagging. Commencing in early June 2000, upstream-migrating adult sockeye salmon will be captured during the peak migration period in a trap installed at the head of a deep (6 meter) pool located approximately 75 meters upstream from the mouth of the Ozette River. The trap is comprised of a live box with wings constructed of 2.5 cm mesh net to block upstream migration, and to direct fish into the trap live box. The netting mesh size will allow smolts to pass through when the trap is being actively operated. The net-mesh wings will angle across to a sliding gate leading into an hexagonal, diamond-shaped live box made of 1" mesh netting (~9 feet long by 7 feet wide at widest point) where fish will be individually removed for sampling. Any surplus adults or emigrating smolts will be allowed to pass without handling by opening a portion of the net weir adjacent to the trap. The trap will be continuously attended when in operation. When not actively fishing and after meeting fish capture goals, the entire weir and trap will be removed. Installation and removal of the temporary trap in the lower river will require no construction (i.e., movement of earth), no vegetation removal, no increase in noise levels, no access roads, no power lines, and no channel, hydraulic, or hydrologic modifications.

Adult sockeye salmon will be randomly selected for capture during the peak June adult in-migration period. Operators will individually remove adult sockeye salmon from the trap live box using a dip net. Immediately upon capture of the 115 sockeye salmon targeted for collection, a total of 100 will be individually placed into a 100-gallon, covered tote containing an appropriate concentration (50-100 ppm) of tricaine methane sulfonate (MS-222), an approved fish anesthetic. Once anesthetized, they will be externally examined and photographed to form a record of the incidence of scarring. The examination will include recording the presence or absence of predator marks (via written record and photograph), measurement of the marks, and later categorization of the marks as to severity and likely cause. Marks caused by otters, seals, or sea lions will be determined by measuring canine or claw mark distances. These measures, and the location of the marks on fish, have been reliably used by Pacific Northwest marine mammal researchers to identify species responsible for predator marks on salmonids (P. Gearin, NMFS, pers. comm.). The relative freshness of the marks will also be determined.

Anesthetized fish will also be sampled to collect morphometric and meristic (age) data. Morphometric sampling will include collection of fork length and weight data from each individual fish. Three scales will be collected for age determination from each fish. Each of the 100 fish will then be externally tagged in the dorsal musculature with plastic, individually-numbered, color-coded Floy-type tags for later identification. After tagging, the fish will be placed back into the trap live box and allowed to recover. The fish will be held in the trap live box for approximately 15 minutes, or until the fish regains equilibrium and is fully recovered from anesthesia. When the fish have recovered, the upstream trap live box door will be opened, allowing the sockeye salmon to volitionally exit.

As a risk minimization measure upon initiation of the study, 15 of the 115 fish captured by the Makah Tribe will not be anesthetized or examined, and only minimally handled, then tagged with individually-numbered, color-coded Floy-type tags as a control group for later recapture and identification. The relative survival of these 15 adults will be compared with that of 15 anesthetized and tagged adults (from the 100 identified above) recaptured during the first week in June of 2000 to evaluate capture, handling, and tagging effects on the adult sockeye salmon before the full experiment commences. The results of this evaluation will be used to adjust the sampling program for the remainder of the June trapping period, if needed, to minimize any adverse effects that may result from sampling and anesthetization protocols.

2. *Proposed sockeye salmon capture actions in the upper Ozette River.*
In conjunction and commensurate with lower river trapping efforts, the Makah Tribe proposes to capture up to 145 adult sockeye salmon at the adult weir in the upper Ozette River located just below the Lake outlet. Of the 145 sockeye salmon targeted for collection, up to 115 will be fish previously tagged and released in the lower river. The remainder (30 fish) will be collected specifically for the proposed sockeye salmon hydroacoustic/radio tagging study (see below).

Sockeye salmon adults in the upper Ozette River will be trapped during the peak migration period in June at the existing adult sockeye salmon counting weir operated annually by the Makah Tribe for stock assessment purposes. Upstream-migrating salmonids are normally enumerated at the site by Makah tribal staff using underwater video cameras or through visual observation. Under the proposed action, adult sockeye salmon arriving at the existing counting weir will be allowed to enter a two-way trap live box positioned on the opposite side of the counting weir. The opening used to count fish will be closed during operation of the trap. Pickets on the existing weir will be removed opposite of the current location of the underwater camera to create a 0.75 meter opening. Adult sockeye salmon entering this opening will continue through a 2.5 meter entrance (needed to clear the angled weir pickets which angle upstream approximately 6 feet) into a hexagonal live box (9 feet long by 7 feet wide) with 2 sliding gates (one at each end) which will be closed to retain the fish upon entry. Adults retained for sampling will then be allowed to pass through a gate on one side of the upstream end into a 1.5m X 2.5m rectangular cage for removal for sampling. Adults not sampled will be allowed to pass without handling by opening the other upstream gate leading back into the river above the weir. The live box will be actively operated and attended full time by Makah Tribe or NMFS MML personnel. The trap and weir design allows downstream-migrating juvenile salmonids to pass freely through the trap mesh and weir pickets without handling or emigration delay.

Using methods described above for the lower river trapping operation, up to115 recaptured sockeye salmon will be anesthetized for handling, then weighed, fork length measured, photographed, and examined for predator scarring and condition. By comparing the scarring rates in the lower and upper river, the Makah Tribe proposes to determine if fish are being attacked in the river and where the predation is occurring (upper versus lower river). Comparison of scars observed on the fish collected at the lower river trapping site to those observed in the upper river will also provide the proportion of scars caused during the sockeye salmon ocean migration period to new scars obtained in the river. Examining the type and severity of new scars on fish reaching the upper weir site will allow for identification of the predator(s) in the upper river.

3. *Collection of river otter and harbor seal abundance, activity, and food habit data.*
The Makah Tribe proposes to collect additional information to improve scientific understanding regarding the occurrence and effects of predation on listed Ozette Lake sockeye salmon. Additional actions to collect this information include visual observations of harbor seals and river otters and the collection of seal and otter scat for diet analysis in the Ozette River Basin. These proposed actions, which are more fully described in the Makah Tribe's study proposal that is the subject of this Opinion (Makah and NMFS 2000), will not lead to any taking of listed sockeye salmon. Directed monitoring of harbor seal and river otter occurrence, behavior and food habits, although needed to assess predation rates on sockeye salmon, will therefore not be authorized by NMFS through this Opinion. This Opinion will address only those actions in the predation study proposed by the Makah Tribe that may affect sockeye salmon.

B. Combined Acoustic/Radio Tagging, Tracking, and Hydroacoustic Survey.
The other primary objectives of the proposed research include, through implementation of a pilot study, the identification of spawning sockeye salmon distribution, abundance, spawning habitat utilization, and reproductive success in Ozette Lake. These objectives are proposed to be met by tagging up to 45 sockeye salmon captured in conjunction with the predation research portion of the program with combined radio and acoustic tags, tracking the distribution and relative abundance of sockeye salmon in Ozette Lake through monitoring of tagged fish, and conducting hydroacoustic surveys of adult sockeye salmon holding in Ozette (Makah and NMFS 2000).

1. *Proposed sockeye salmon tagging actions in the upper Ozette River.*
Thirty fish will be collected in conjunction with the recapture of 115 sockeye salmon for the predation study at the upper Ozette River site during the month of June, 2000 (the peak sockeye salmon migration period) for the specific purpose of deploying combined acoustic/radio transmitters. These 30 fish will be "new" fish that were not previously captured in the lower Ozette River for the predation assessment study. The Makah Tribe also proposes that up to15 additional sockeye salmon recaptured as part of the predation assessment study be either tagged with a combined acoustic/radio transmitter for the telemetry study, or tagged externally with a Floy-type tag. The total number of sockeye salmon that may be tagged for this portion of the research study would therefore be 45.

Fish selected for tagging will be captured, handled, and biological sampled using methods identical to those applied for fish taken for the predation study. However, sockeye salmon selected for acoustic/radio tagging will anesthetized using clove oil instead of MS-222. Clove oil is a natural, non-carcinogenic anesthetic that is now widely used on fish, and has been shown to anesthetize fish faster, and allow the fish to regain equilibrium faster than MS-222. A 20-30 ppm "maintenance" dose of clove oil will initially be used to anesthetize the fish for handling. Fish on the maintenance dose are then fully anesthetized in 50-60 ppm clove oil, and placed on their backs onto a V-shaped trough for tagging. During the 4-5 minute tag implantation or insertion procedure, the fish's head will remain submerged in a recirculating maintenance concentration of clove oil, which is continually irrigated over the gills/head. Since safe and effective concentrations of any anesthetic may vary among different fish species and life stages, clove oil concentrations will be gradually increased to the above, desired levels to appropriately monitor effects.

The sockeye salmon will be tagged with combined acoustic/radio transmitters (CART 16 1S). These tube-shaped tags measure 16 mm x 48 mm (0.6" x 1.9") and weigh 22.8 grams. The tags have a 180-day battery life, alternate between acoustic and radio frequencies, and pulse every eight seconds. The combined acoustic/radio transmitters will be surgically implanted into the peritoneal cavity of male sockeye salmon using methods described in Beddow et al. (1998). Tag-induced mortality using the proposed surgical procedure is expected by the action agencies to be less than 2% (1 fish) (Makah and NMFS 2000). The tags for female sockeye salmon in the 30 fish sample will be implanted in the oviduct, and no tag-induced mortality using this method is expected. After the tags are implanted or inserted, the fish will be allowed to recover in fresh lake water and then volitionally released.

2. *Proposed tagged sockeye salmon monitoring actions in Ozette Lake*.
The initial purpose of this study in 2000 is "a proof of concept" for expanded study in subsequent years. Full, quantifiable hydroacoustic surveys of the entire lake may take several weeks and be very expensive. The Makah Tribe therefore proposes that survey work in 2000 be conducted as a pilot study, beginning with capture, tagging, tracking, and hydroacoustic survey. This pilot research will be a precursor to research in subsequent years including a statistically valid number of tagged fish, and complete hydroacoustic surveys of the entire lake. For the pilot study in 2000, the Makah Tribe proposes to determine the types of tags needed, to train personnel to track adult sockeye salmon in the lake, and to remedy problems that are identified relating to tracking fish distribution. To track tagged sockeye salmon, the Makah Tribe proposes to conduct two types of hydroacoustic surveys in deep and shallow water to quantify fish abundance, and to learn more about how the fish are aggregated and the characteristics of the habitat they occupy.

Past observations by the Makah Tribe have documented large schools of adult sockeye salmon staging near Ozette Lake spawning beaches by late-summer to early fall. Also, research in other Washington regions has shown that holding adult sockeye become concentrated in late summer in thermally stratified zones. For example, when the thermocline in Lake Washington is at its maximum depth of approximately 12 m in late summer, all of the adult sockeye are concentrated in a zone between 12-67 m which is ~ only 1/3 of the lake). The Makah Tribe will therefore conduct a late-summer split-beam acoustic survey of the lake, focusing upon areas of known aggregation of tagged individuals. A pilot side-scan multi-beam sweep of the lake will also be conducted during the sockeye salmon spawning period to estimate position and numbers of sockeye in shallow and transitional depth zones.

Tracking will be accomplished primarily by boat in Ozette Lake and by foot in the tributaries. A LOTEK SRX_400 W5A scanning receiver will be used to manually track the coded transmitters. Connected to the receiver will be a four element Yagi antenna and an active omni-directional hydrophone. The hydrophone will be housed in a 45-degree directional baffle. The two sweeps proposed in the lake will occur over 2-3 days, and both will determine the distribution, habitat characteristics, and packing densities within sub-habitats. Both survey sweeps will also quantify staging adults using telemetry, which will be conducted throughout the summer and fall to locate and verify targets. The late summer, split-beam sweep will be "vertically incident" (pointed straight down), which will enable size classification of targets. The second multibeam sweep will incorporate both side-scanning of nearshore, shallow areas and the vertical methods of the first sweep to observe other fish in deeper water. Tracking will be accomplished using remote sensors, and no sockeye salmon are expected to be handled, harassed, or harmed through this portion of the proposed research.

As an outcome of the pilot study, the Makah Tribe will provide a summary report, raw and summary data files from 2000 results, and recommendations regarding an expanded habitat delineation and tracking program in 2001.

II. Status of the species and critical habitat

The Ozette Lake sockeye salmon ESU was listed as "threatened" under the ESA on March 25, 1999 (64 FR 14528). In making this determination, NMFS concluded that the ESU is likely to become endangered in the foreseeable future if present conditions continue. NMFS also concluded that current protective efforts are insufficient to change this forecast of extinction risk. Listed Ozette Lake sockeye salmon are present in the action area, and will be directly and incidentally affected by the proposed actions. The listed sockeye salmon ESU includes all naturally spawned sockeye salmon residing below impassable natural barriers (e.g., long-standing, natural waterfalls) in Ozette Lake and its tributaries. Sockeye salmon stock reared at the Makah Tribe's Umbrella Creek Hatchery are considered part of the ESU, but are not considered essential for recovery of the ESU. NMFS has determined that it is presently not necessary to consider the progeny of intentional hatchery-wild or wild-wild crosses produced through the Makah tribal hatchery program as listed under the ESA (64 FR 14528). However, once hatchery fish return and spawn in the wild, their progeny become listed.

The overall abundance of naturally produced Ozette Lake sockeye salmon is believed to have declined substantially from historical levels. In the 1997 west coast sockeye salmon species review, NMFS reported that current escapements averaged below 1,000 adults per year, implying a moderate degree of risk from small-population genetic and demographic variability with little room for further declines before abundances reach critically low levels (Gustafson et al. 1997). Recent analysis and updating of escapement data by the Makah Tribe indicates that the recent four-year (1996-1999) average run size entering Ozette Lake is 1,598 adults per year (Makah 2000). A multitude of factors, past and present, have contributed to the present, depressed status of Ozette Lake sockeye salmon. Natural environmental fluctuations have likely played an important role in the decline of abundance over the last fifty years. However, human-induced factors have also likely played a significant role in the decline of the ESU. These human-induced factors have likely reduced the species' resiliency to such natural factors for decline as drought and poor ocean conditions. Human induced factors contributing to the decline of the ESU include siltation of lake spawning beaches and widespread sedimentation of outwash fans and key portions of lake tributaries as a result of past intense and frequent timber harvest and associated road building in the Ozette Lake watershed, high harvest rates in fisheries prior to 1974, introduction of non-native fish and plant species, disruption of natural predator-prey relationships; and the interactions of these factors (Gustafson et al. 1997; 64 FR 14528; Makah 2000). These potential factors for decline are discussed in greater detail in NMFS' sockeye salmon status review document (Gustafson et al. 1997) and by Makah (2000). NMFS has expressed concerns regarding potential deleterious genetic effects of present hatchery production and past interbreeding with genetically dissimilar kokanee salmon (Gustafson et al. 1997; 64 FR 14528). These latter issues are perceived risks to the Ozette Lake sockeye ESU, and are not considered factors for decline.

Germane to evaluations presented in this Opinion is the additional concern regarding the effects of marine mammal predation on the presently depressed Ozette Lake sockeye salmon population. NMFS has published recent reports describing the impacts of California sea lions and Pacific harbor seals on the coastal ecosystems of Washington, Oregon, and California (e.g., NMFS 1997). These reports conclude that in certain cases where pinniped populations coexist with depressed salmonid populations, salmon populations may experience severe impacts due to predation. The reports further conclude that data regarding pinniped predation are limited, and that substantial additional research is needed to fully address this issue.

In recent years, harbor seals and river otters have been observed by NMFS MML and Makah tribal researchers to be preying on adult sockeye salmon in the Ozette River (Gearin et al. 1998; 1999-final report pending; Makah and NMFS 2000; Makah 2000). In 1999, river otters were observed on 274 occasions in the Ozette River during the sockeye salmon migration period. Otters were directly observed predating on adult sockeye in 1998 and 1999. In 1999, a remote camera positioned at the upper Ozette River weir recorded 10 instances of direct otter predation of adult sockeye which included footage on three occasions of adult sockeye being carried to and from Lake Ozette. Approximately 10% of the 1999 sockeye salmon return had scar marks visible on one side of the fish, which were often severe (Makah and NMFS 2000). On-site observers in 1999 documented 34 occasions when they could hear or see nocturnal otter predation occurring within 150 meters of the existing Ozette River weir, which included seven direct observations of river otters eating adult sockeye salmon. Harbor seals transit up the Ozette River into Ozette Lake, and have been seen feeding on adult sockeye salmon in the river and off of the spawning beaches in Ozette Lake (Makah Tribe unpublished data; Gustafson et al.1997; Gearin et al. 1998). There is extensive overlap between harbor seals and adult sockeye salmon during their annual April through late-July upstream migration period in the Ozette River, during their lake holding period (April through October) and particularly during spawning along the lake beaches (October through March annually). Camera data from the weir on the upper river in 1999 recorded harbor seals swimming through the weir at least 20 times. Harbor seals were observed preying on sockeye salmon within 150 meters of the weir on five occasions by staff attending the weir (Makah Tribe unpublished data). Harbor seals were observed by on-site staff and through underwater camera recordings directly predating on sockeye in the Ozette River in 1998 and in 1999. Images of harbor seals passing the weir location with adult sockeye salmon in their mouths were captured on camera in both years (Makah Tribe unpublished data).

Seal predation on sockeye salmon on the spawning beaches appears to be an even greater problem. It is presumed that sockeye salmon spawners in shallow water near the Ozette Lake shoreline may be highly susceptible to seal predation. National Park Service and Makah tribal personnel have observed seals in the lake ranging from May through December in past years, and seals have been observed chasing adult coho salmon up onto the lake shoreline. It is presumed that seals follow the adult coho salmon run into the lake when water levels are high in the fall and winter. It appears that several individual harbor seals have learned the location of both beach spawning sockeye salmon populations, and have focused predation on beach spawning Lake Ozette sockeye. Boat surveys were conducted weekly in Lake Ozette during the spawning season from October through December in 1998 and weekly scuba surveys of the main spawning sites were conducted by Makah Tribe and Olympic National Park divers in 1999. These surveys documented the presence of harbor seals in Ozette Lake six times when single seals were observed. Seals were observed during the peak spawning season at both Allen's and Olsen's Beaches. The 1998 and 1999 investigations determined that harbor seals have a high degree of spatial and temporal overlap with Ozette Lake sockeye salmon during the spawning season when adults are most vulnerable. Sockeye salmon heads, bitten off at the operculum, were recovered on nearly all surveys. Further studies in 2000 and beyond will attempt to quantify predation losses by harbor seals and river otters, to determine where and when the predation occurs, and to indicate to what extent recovery of Ozette Lake sockeye is impacted.

Prior to the listing of the ESU in 1999, the Ozette Lake sockeye salmon population was classified by WDFW and the Washington coastal tribes as of native origin, of wild production type, and depressed in status based on chronically low escapements (WDF and WWTIT 1994). In the 1997 sockeye salmon population status review, Gustafson et al.(1997) reported a negative short term (1986-95) abundance trend for the Ozette population (-9.9 average percent annual change) and a slightly negative long term (1977-96) trend (-1.5 average percent annual change). A more recent evaluation of population abundance data provided by the Makah Tribe (Makah Tribe 2000) suggests stable or increasing short and long term trends for the Ozette Lake sockeye salmon ESU. The 1977 to 1995 mean annual sockeye salmon run size entering Ozette Lake from Ozette River was estimated to be 952 adults (Jacobs et al. 1996). The mean run size from 1986 to 1995 was 851 adults. The mean run size from 1977 to 1980 was 724, while the most recent mean run size over the past four years (1996-1999), reflecting the most recent four sockeye salmon brood cycle year returns, was 1,598 (Makah Tribe 2000).

The Makah Tribe has forecasted a return of approximately 3,000 sockeye salmon to the Ozette Lake Basin in 2000 (M. Crewson, Makah Tribe, pers. comm.). This forecast assumes a wild Ozette Lake sockeye salmon return equal to the estimated cycle year (1996) wild sockeye salmon run size of 1,700 fish (57 % of the total 3,000 fish return). The hatchery-origin component of the return was forecast by applying a 0.6 % survival rate to the '96 brood year Umbrella Creek Hatchery juvenile sockeye salmon release of 209,562 (1,257 fish, or 43 % of the total return). Ozette Lake sockeye salmon are known to spawn at two principle shoreline spawning beaches in the lake. These spawning areas include Olsen's Beach, north of Siwash Creek on the lake's western shore and the beach area north of Allen's Bay, on the lake's western shore (WDF and WWTIT 1994). Mature adult sockeye salmon in Ozette Lake have also been reported near the south shore of Baby Island at the southern end of the lake, in Ericson's Bay (Gustafson et al 1997 quoting Jacobs et al 1996), and near Umbrella Creek (WDF and WWTIT 1994; Jacobs et al 1996). Historically, Ozette sockeye salmon also spawned in tributaries to Ozette Lake, potentially including Big River, Umbrella Creek, Crooked Creek, and in the Ozette River (WDF and WWTIT 1994; Jacobs et al. 1996). The Makah Tribe's sockeye salmon hatchery program has apparently been successful in seeding Umbrella Creek, leading to the re-establishment of significant natural spawning levels in that tributary. Peak adult sockeye salmon observations in Umbrella Creek in 1995 were 19 fish per mile. Peak counts in 1999 were 138 adults per mile (Table 1, from Makah Tribe 2000). Of the 138 spawners per mile observed in Umbrella Creek in 1999, it was estimated that 38 % (52/138) were natural origin recruits, yielding an adult replacement rate of 2.7 (Table 1; Makah Tribe 2000).

Table 1. Peak adult sockeye salmon counts from Umbrella Creek (RM 4.78 to 2.52; Makah Tribe 2000).

Year	Hatchery Releases1	Adult Sockeye	Distance (mi)	Peak Fish/Mile	Peak NOR/Mile
1995	48,1862	44	2.26	19	na
1996	No Release	79	2.26	35	35
1997	39,0403	135	2.26	60	na
1998	44,4113	96	2.26	425	na
1999	45,2204	312	2.26	138	52

[1] Hatchery releases correspond to return years not release years (3 years prior to adult returns).
[2] 48,186 fingerlings were the combined lake and creek releases of which 7,645 were released into Umbrella Creek.
[3] Lake release only.
[4] All fish were released into Umbrella Creek.
5 Surveys didn't include the peak spawn timing due to excessive turbidity.

Results of genetic analyses indicate that the spawning populations at Olsen's Beach and Allen's Bay are genetically distinct from one another (Gustafson 1999). NMFS has indicated a concern for the potential hybridization of tributary spawning sockeye salmon resulting from the Makah Tribe's hatchery program with the indigenous kokanee salmon population. The perceived risk is that such hybridization might lead to deleterious genetic effects, decreasing the genetic diversity of the populations, and potentially their survival fitness (Gustafson et al. 1997; Gustafson 1999). Contributing to this concern is the finding that the kokanee population currently spawning in other Ozette Lake tributaries is the most genetically distinct O. *nerka* population in the Pacific Northwest (Gustafson et al 1997). To address concerns for hybridization and genetic introgression effects, the Makah Tribe has proposed to continue to limit tributary reintroduction of sockeye salmon to Umbrella Creek and Big River, where there are no documented self-sustaining kokanee populations (Makah Tribe 2000). Also, no straying to lake spawning beaches of adults resulting from sockeye salmon planted in the tributaries has been observed (Makah Tribe 2000). The Makah Tribe, in conjunction with the Northwest Indian Fisheries Commission, has ben funded to conduct research to monitor the genetic composition of all potential subpopulations of Ozette Lake sockeye salmon and kokanee salmon (Makah Tribe 2000). The genetic profile created will be used to compare similarities among these two known beach spawning populations. The profile may also help identify potential genetic markers that can be used to design and implement monitoring for hybridization between kokanee and sockeye salmon that might result from the Makah Tribe's tributary-spawning sockeye salmon reintroduction effort.

An annual spawning escapement goal applied by the co-managers (the tribes and WDFW) to meet production objectives in Ozette Lake has not been established. As previously mentioned, the most recent four year mean run size from 1996 to 1999 for this predominately four-year-old age at return stock was 1,598 adults (range 1,133 to 2,076; Makah Tribe 2000). Recent re-calculation of past run size estimates by the Makah Tribe based on complete sets of hard data from camera and visual weir counts suggest a stable or increasing trend in escapements to the lake (Makah Tribe 2000). Although spawning counts have been conducted in lake tributary areas, the number and distribution of spawners among Ozette Lake beach spawning areas is unknown. Scuba, snorkel, and boat surveys of known beach spawning areas in Ozette Lake have been unsuccessful in accounting for the number of sockeye salmon estimated to have entered the lake. The results of these surveys suggest the existence of other, yet to be identified beach spawning areas, or high pre-spawning mortality rates during the five to six month lake holding period.

Critical habitat was designated in the Federal Register as a final rule for the Ozette Lake sockeye salmon ESU on February 16, 2000 (65 FR 7764). Critical habitat designated in this Federal Register Notice includes all lake areas and river reaches accessible to listed sockeye salmon in Ozette Lake. Excluded are areas above longstanding, naturally impassable barriers in the above, defined area (i.e. natural waterfalls in existence for at least several hundred years).

Thirteen species of fish are thought to occur in Ozette Lake (Gustafson et al 1997). In addition to sockeye salmon, Ozette Lake and the Ozette River Basin harbor several other species of salmonids: coho salmon, chum salmon, chinook salmon, kokanee, steelhead, and sea-run cutthroat trout (Beauchamp et al.1995; Jacobs et al.1996; Makah Tribe 2000). The proposed sockeye salmon trapping locations in the Ozette River may be used for spawning or rearing, and as a migration corridor, by coho salmon, chum salmon, chinook salmon, steelhead, and sea-run cutthroat trout. Resident salmonids, including cutthroat trout, kokanee, and rainbow trout, and rearing juvenile anadromous salmonids, including coho salmon, sea-run cutthroat trout, and steelhead may be encountered during proposed seal, otter, and tagged sockeye salmon surveys in Ozette Lake. Non-salmonid fishes that could be affected by the proposed sampling and monitoring program in the Ozette Basin include northern pikeminnow (*Ptychocheilus oregonensis*), Olympic mudminnow (*Novumbra hubbsi*), Pacific lamprey (*Entosphenus tridentata*), River lamprey (*Lampetra* ayresi), prickly sculpin (*Cottus asper*), largemouth bass (*Micropterus salmoides*), yellow perch (*Perca flavencens*), peamouth (*Mylocheilus caurinus*), and red-sided shiner (*Richardsonius balteatus*) (Gustafson et al 1997; Makah Tribe 2000). Dolly Varden/Bull trout, which are listed as "threatened" under the ESA, are not present in the Ozette River Basin (WDFW 1999).

A "Species List" identifying listed and proposed threatened and endangered species, candidate species, and species of concern provided by the USFWS also indicates that listed Dolly Varden/bull trout are not present in the action area (USFWS 2000), and no effects to this listed species or their designated critical habitat are expected. The USFWS has indicated in the "Species List" that there are four bald eagle (*Haliaeetus leucocephalus*) nesting territories in the vicinity of the proposed research project (USFWS 2000). Bald eagle nesting activities occur from January 1 through August 15, over-lapping the June action period proposed for sockeye trapping. Survey actions proposed for the project will occur during the October 31 through March 31 bald eagle wintering period. The USFWS "Species List" also notes that the northern spotted owl (*Strix occidentalis caurina*) occurs in the vicinity of the Ozette research project. Nesting activities for this species occur from March 1 through September 30 (USFWS 2000).

III. Biological Requirements and Environmental Baseline

The standards for determining jeopardy are set forth in Section 7(a)(2) of the ESA as defined by 50 CFR Part 402 (the consultation regulations). NMFS must determine whether the proposed actions are likely to jeopardize listed species and whether they are likely to destroy or adversely modify critical habitat. This analysis involves the initial steps of (1) defining the listed species' biological requirements, and (2) evaluating the relevance of the environmental baseline to the species' current status. Subsequently, NMFS evaluates whether the actions are likely to jeopardize the listed species by determining if the species can be expected to survive the effects of the actions with adequate potential for recovery.

In making the above determination, NMFS must consider the estimated level of mortality attributable to: (1) the collective effects of the proposed or continuing action, (2) the environmental baseline, and (3) any cumulative effects. This evaluation must take into account measures for survival and recovery that occur beyond the action area. If NMFS finds that the action is likely to jeopardize, NMFS must identify reasonable and prudent alternatives to the action.

Furthermore, NMFS evaluates whether the actions, directly or indirectly, are likely to destroy or adversely modify the listed species' critical habitat or appreciably reduce the value of the critical habitat. NMFS must determine whether habitat modifications appreciably diminish the value of critical habitat for both survival and recovery of the listed species. To do so, NMFS identifies those effects of the actions that impair the function of any essential element of critical habitat. NMFS then considers whether such impairment appreciably diminishes the habitat's value for the species' survival and recovery. If NMFS concludes that the actions will adversely modify critical habitat, it must identify reasonable and prudent measures to prevent the modification.

A. Biological Requirements of Sockeye Salmon

The first step in the method NMFS uses to apply ESA standards of section 7(a)(2) to listed salmon is to define the biological requirements for the listed species relevant to the consultation. NMFS also considers the listed species' current status by taking into account population size, trends, distribution, and genetic diversity. To assess the species' current status, NMFS begins with the analysis made in its determination to list the particular species for ESA protection and adds to it any new data that is relevant to the determination.

The relevant biological requirements are those necessary for the listed species to survive and recover to naturally reproducing population levels high enough that protection under the ESA would become unnecessary. These biological requirements include the quantity and quality of natural freshwater and marine area habitats necessary to effect incubation, hatching, and emergence in freshwater, migration to the ocean, and subsequent return to freshwater for completion of maturation and spawning, so that the population can sustain itself. Adequate population levels must be ensured to safeguard the genetic diversity of the listed stocks, enhance their capacity to adapt to various environmental conditions, and allow them to become self-sustaining in the natural environment.

The current status of the natural sockeye salmon population in Ozette Lake is described above. Abundance estimates provided by the Makah Tribe based on recent hard counts of adults migrating through the upper Ozette River counting weir indicate that the short-term trend in sockeye salmon abundance, as measured by fish entering the lake, may be stable or increasing. As noted previously, the average escapement to the upper Ozette River over the last four years is estimated to be 1,598 (range 1,133 to 2,076).

Estimates of historic (1977 through 1996) abundance of sockeye salmon returns to the Ozette Basin are available, and the status of the population has been indicated above for this period (WDF and WWTIT 1994; Jacobs et al.1996; Gustafson et al. 1997; Makah Tribe 2000). Estimates of return levels to the watershed prior to this period cannot be considered accurate due to the lack of consistent escapement survey data and methods, and because no precise data are available to estimate intercepting fishery exploitation rates for Ozette-origin sockeye salmon. However, anecdotal reports of tribal sockeye salmon harvest levels near the mouth of the Ozette River approaching 18,000 in 1949 suggest that the Ozette sockeye salmon return was once much larger than the present average run size of 1,598. Assuming that tribal sockeye salmon harvests at that time consisted of sockeye salmon destined to spawn in the Ozette system, catch estimates during the mid-1900s would indicate that recent abundance is substantially below the historical abundance range for the ESU (Gustafson et al. 1997). However, there has been no harvest of Ozette Lake sockeye salmon for the past four brood cycle years (16 years). Prior to that time, in the 1970s and early 1980s, minimal ceremonial and subsistence harvests by the Makah Tribe ranged from 0 to 84 fish. Over the ten years prior to the early 1970s, commercial harvests by the Makah Tribe remained minimal, averaging less than 500 fish. Tribal harvest of Ozette Lake sockeye salmon has not likely to have been a significant mortality factor for the population in over 35 years. In addition, due to the early river entry timing of returning Ozette Lake sockeye salmon (late April start, with peak returns prior to late May or mid-June), the fish are not intercepted in Canadian and U.S. marine area fisheries directed at Fraser River sockeye salmon. There are currently no known marine area harvest impacts on Ozette Lake sockeye salmon.

Artificial propagation in the Ozette Basin has not been extensive. Although few in frequency and number, sockeye salmon releases into Ozette Lake in some years have originated from non-indigenous stocks. In 1937, sockeye salmon fingerlings thought to be of Baker Lake (Skagit River Basin) stock were planted by the U.S. Bureau of Fisheries in the lake. In 1983, the Makah Tribe planted Lake Quinault stock sockeye salmon fry into Ozette Lake. The genetic effects of these introductions are unknown. Recent year artificial propagation programs have used Ozette Lake-origin sockeye salmon stock accessed from the lakeshore spawning grounds. Between 1984 and 1995, almost 500,000 Ozette Lake-origin sockeye salmon fry were reared at the Makah tribal hatchery on Umbrella Creek and released into the Ozette Lake drainage (Gustafson et al. 1997). In the 1997 sockeye salmon status review, NMFS reported that the release of a small number of kokanee/sockeye salmon hybrids in 1991-92 may have had deleterious effects on the genetic integrity of the ESU because Ozette Lake kokanee are genetically dissimilar to Ozette Lake sockeye salmon (Gustafson et al. 1997). The Makah Tribe has indicated that these hybrid releases likely had little or no effect on the genetic integrity of the ESU because the release comprised less than 3 % (1990) to less than 6 % (1991) of the total fry production estimated for the Ozette Basin that brood year. Survival of the kokanee/sockeye salmon hybrids was expected to be low, and no adult hybrid returns were ever identified (M. Crewson, Makah Tribe, pers. comm.).

The Makah Tribe proposes to continue a hatchery-based reintroduction program in the system using sockeye returns re-established in Umbrella Creek as broodstock. The focus of the hatchery program will be on the continued reestablishment of sockeye salmon in Ozette Lake tributary spawning areas, to use these releases as a tool to learn more about the survival and productivity of natural origin recruits, and to monitor any potential interactions among the hatchery and wild populations. The proposed artificial propagation program, and associated research, will be evaluated by NMFS for effects on ESA-listed fish under a separate section 7 consultation.

B. Environmental Baseline

The biological requirements of Ozette Lake sockeye salmon are currently not being met under the environmental baseline. Their status is such that there must be a significant improvement in the environmental conditions of the designated critical habitat over those currently available under the baseline. Any further degradation of these conditions would have a significant impact due to the amount of risk the listed populations presently face under the environmental baseline.

A multitude of factors, past and present, have contributed to the decline of Ozette Lake sockeye salmon (64 FR 14528). As mentioned previously, contributing to current, depressed abundances are degradation of lake and tributary spawning areas through siltation caused by poor forestry practices and associated road building, over-harvest in fisheries occurring prior to 1974, disruption of natural predator-prey relationships, introduction of non-native fish and plant species, and the interactions of these factors. A hazard to the present population identified by NMFS is the potential increased risk of loss of genetic diversity due to past interbreeding with genetically dissimilar kokanee. Predation by marine pinnipeds in marine and freshwater areas, and by river otters in freshwater areas, used by Ozette sockeye salmon for migration and spawning are also concerns. NMFS also believes that natural environmental fluctuations have likely played a role in the decline of these species. Resultant low run sizes have led to a concern for genetic risks posed by small population and demographic variability, with little room for further decline (FR 64 14528). Potential factors for decline and current potential hazards to the listed ESU are discussed in greater detail in NMFS' sockeye salmon status review document (Gustafson et al. 1997).

As noted in NMFS' sockeye salmon status review (Gustafson et al. 1997), and in the Federal Register Notice announcing the formal listing of the ESU (64 FR 14528), habitat in the Ozette Lake watershed where the research programs are proposed is considered degraded. Land use on private and state lands adjacent to the research sites is principally devoted to forest practices. Outside of the portion of the Ozette Basin that is included in the Olympic National Park, virtually the entire Ozette Lake watershed has been logged. Among the changes attributable to past forest practices (including intensive logging and associated road building in the watershed prior to state regulation of forest practices) is degradation through siltation of streams, tributary outwash fans, and beach areas historically used by sockeye salmon. The increased sediment load in the tributaries, with settling of much of the finer sediment in the lake, likely limited what was a more widespread sockeye salmon spawning distribution in the lake and the tributaries to a few less affected beach areas on the south end of Ozette Lake (WDFW and WWTIT 1994). Dlugokenski et al. (1981) suspected that logging-induced sedimentation led to decreased hatching success of sockeye salmon in the tributary creeks and creek outwash fans in Ozette Lake. Sedimentation of key portions of lake tributaries, spawning beaches, and outwash fans as a result of timber harvest and road building may not have caused the declining sockeye salmon abundance, but has contributed to the failure of Ozette Lake sockeye salmon populations to rebuild since the cessation of commercial sockeye salmon harvests in the region in 1974 (FR 64 14528). As noted previously, no Ozette Lake sockeye salmon harvest has occurred since 1982. In addition to increased sediment loads, past forest practices in the major Ozette Lake tributaries that also contributed to channel instability (as indicated by stream widening and shallowing), cementing of spawning gravels, loss of pools, bank erosion, and high water temperatures have likely limited sockeye salmon productivity (WDF and WWTIT 1994).

IV. Effects of the Proposed Actions

A. Effects on Listed Sockeye Salmon

Research and monitoring activities are not identified in the NMFS sockeye salmon ESA status review as factors contributing to the decline of Ozette Lake ESU sockeye salmon. However, due to a general lack of data, and therefore, uncertainty, regarding the status and life history characteristics of natural-origin sockeye salmon in the Ozette system, one cannot conclude that the numbers of adult fish handled for this research will not have a significant effect on the continued existence of the species. Trapping on the Ozette River will occur throughout the major portion of the adult sockeye salmon migration period, and will involve the capture of listed naturally produced adult fish, and the capture of hatchery fish produced through the Makah Tribe's Umbrella Creek Hatchery project. Hatchery-origin sockeye salmon are not considered essential for recovery of the listed ESU, and are not included as part of the listed population (64 FR 14528). However, not all of the hatchery-origin sockeye salmon can be visually differentiated from listed natural-origin sockeye salmon due to the lack of 100 % external marking of hatchery fish. Due to the proposed timing and location of the proposed adult trapping program, minimal overlap of the project with the sockeye salmon smolt seaward emigration period (early May peak), and the use of trapping methods that allow free, unobstructed downstream passage of small fish, no listed juvenile sockeye salmon are expected to be taken through the proposed research, and no mortalities of juvenile fish are likely. No adverse effects are expected on listed juvenile Ozette Lake sockeye salmon. The focus of this Opinion is therefore the evaluation of the effects of the research program on natural-origin adult sockeye salmon.

This is a new project, scheduled to begin in early June 2000. Trapping in the Ozette River directed at adult sockeye salmon will be conducted throughout the month of June, comporting with the peak in-migration period for sockeye salmon returning to Ozette Lake. Take effects associated with adult sockeye salmon trapping will include capture, anesthetizing, handling, sampling, tagging, and release of listed sockeye salmon. Additional take effects may include injury or incidental mortality of sockeye salmon trapped and handled, and migrational delay and increased susceptibility to predation for sockeye salmon encountering the proposed trapping operations. Monitoring of harbor seal and otter occurrence and predation, and tracking of tagged sockeye salmon, will occur in the Ozette River, Ozette Lake, and the tributaries from June through December, 2000, encompassing the listed sockeye salmon lake holding and spawning period. Take effects associated with these actions may include harassment of migrating or holding adult sockeye salmon encountered in the Ozette River, Ozette Lake, in the tributaries.

The Makah Tribe proposes to actively operate the lower and upper Ozette River traps to selectively capture up to 115 sockeye salmon at the lower river site, and up to145 sockeye salmon at the upper river site. Of the 145 fish targeted at the upper river site, 115 will be fish recaptured from those tagged on the lower river. Although representing recaptures, for ESA impact evaluation purposes, actions directed at these fish at the upper Ozette River trapping site are considered additional takes (i.e. for ESA permits, a fish is considered "taken" each time it is captured).

Considering the lower river trapping effects, the total number of sockeye salmon adults that will be captured, anesthetized, handled, sampled, tagged, and released will therefore be 115, or 3.8 % of the total forecasted sockeye salmon return of 3,000. The upper river operation will lead to the recapture, anesthetizing, handling, re-sampling, and release of these 115 sockeye salmon. The same 3.8 % of the migrating sockeye salmon population will be taken through recapture. The action agencies plan to adjust proposed handling and tagging protocols to minimize any adverse effects to fish, if identified through evaluation of 15 sockeye salmon exposed to minimal handling during the first week of operation.

An additional 30 sockeye salmon will be captured, anesthetized, handled, hydroacoustic tagged and released at the upper river trapping site for the sockeye salmon migration monitoring project. None of these fish will have been previously handled through the lower river trapping program. Of the 115 recaptured sockeye, 15 may also be hydroacoustic tagged. Combined acoustic/radio tags may therefore be implanted surgically (males) or in the oviduct (females) in up to 45 fish at the upper river trap (30 “new” fish and 15 recaptured fish). In total, 145 individual fish are proposed to be selectively taken through trapping proposed for the Makah Tribe research program, or 4.8 % of the total forecasted return of 3,000 fish. Of this number,115 adult sockeye (3.8 %) will be taken twice through the proposed program.

Takes through injury or mortality may occur on the 115 sockeye salmon that will be captured, anesthetized, handled, sampled, tagged externally and released in the lower river trapping location, then recaptured at the upper Ozette River trap. Stress, descaling, and possible injury of the fish are possible through initial capture and handling, and recapture, potentially leading to delayed mortality, or a decreased potential for successful spawning. These fish may also have an increased susceptibility to predation through impaired short-term ability to avoid predators, or by placement of the Floy-type tags which may make the fish more visible to predators. Salmon trapping and release programs similar to those proposed by the Makah Tribe have minimal incidental mortality levels, usually below 1 % of the total number of fish handled (L. Brown, WDFW, pers. comm.; E. Hockersmith, NMFS, pers. comm.). Given proposed recapture of the same 115 sockeye salmon adults, the above, low expected incidental mortality level may be considered additive, leading to a mortality rate of 2 % of total number of fish handled (2 fish). The allowance for adequate recovery of the sockeye salmon in trap live boxes prior to upstream release may reduce the potential for post-release mortality (Makah Tribe and NMFS 2000). This procedure should help ensure that the susceptibility of handled fish to predation after release is not increased relative to sockeye passed through the traps without handling.

Up to 45 of the sockeye salmon adults proposed for collection will receive combined acoustic/radio tags through the proposed research program. In addition to the affects described above resulting from capture and handling, the additional process of radio/acoustic tagging the sockeye salmon may cause injury and mortality. The action agencies report that surgical implantation of the tags into the fish’s peritoneal cavity of male adult sockeye salmon may lead to incidental mortality of less than 2 % of the number of fish tagged (~1 fish out of 22 tagged) (Makah Tribe and NMFS 2000). This low, expected incidental mortality rate was corroborated by NMFS staff experienced in surgical tag implantation techniques, who estimated that a 3 % loss rate should be expected (E. Hockersmith, NMFS, pers. comm.). The sockeye salmon collected for tagging have just entered freshwater from the ocean, and may have a heightened susceptibility to handling due to the physiological stress of adapting to the osmotic change. Monitoring is required to determine if loss rates are higher than expected for sockeye salmon receiving surgically implanted tags. Radio/acoustic tags inserted through the oviduct in females is less invasive, and likely to pose a decreased risk of post-release mortality for tagged fish. Spawning success of female fish may be affected by this tag insertion method, however. Assuming a 1 % mortality rate, capture and handling of 30 fish that were not taken previously may lead to an additional loss of 1 fish. Tracking tagged fish in the lake should provide information on post-release mortality levels and reproductive success. Information bearing on reproductive success that will be collected includes identification of where fish are spawning in the lake, what types of spawning and incubation habitat the fish are using, and the abundance of fish at identified spawning locations.

As described previously, active operation of the traps by tribal and Federal personnel will allow for the selection of the 145 sockeye salmon for the program, and the free upstream passage, without handling, of other sockeye salmon encountering the traps. When not actively operating, the net-mesh wings and live box used to collect fish in the lower Ozette River will be removed, and the counting weir in the upper river will be opened to allow unobstructed fish passage. Therefore, the remaining 2,855 adult sockeye salmon in the forecasted return (approximately 95 % of the total return) will not be captured and handled, but will be allowed to pass freely upstream. A portion of these 2,855 fish may be affected through the program through migration delay, if the fish are reluctant to enter the trap live boxes, when in operation, during their upstream migration. If migration delay is a factor associated with the traps, these fish may also be made more susceptible to predation by harbor seals and otters if the mammals are present and are targeting fish delayed at the trapping sites. The likelihood for migrational delay, and increased susceptibility to predation, will be minimized by 24 hour surveillance of the trapping sites, and if necessary, opening of the traps to allow upstream fish passage. Beyond potential migrational delay or increased susceptibility to predation, the proposed trapping program is expected to have minimal effects on the majority of the Ozette Lake sockeye salmon return.

Foot and boat surveys conducted to monitor seal and otter occurrence and sockeye salmon predation levels, and to track acoustic/radio tagged sockeye salmon, may lead to contact with and disturbance of migrating, holding, staging, or spawning sockeye salmon in Ozette Lake. Incidental harassment of adult sockeye salmon resulting from the proposed monitoring portion of the program is not expected to pose significant adverse effects on listed fish. Contact with free-swimming sockeye salmon in the lake during monitoring will be limited in duration, and fish may easily avoid surveyors by escaping to deeper waters, or to other locations in the lake.

To minimize the risk of adverse effects posed by the proposed research to listed sockeye salmon, including elevated injury and mortality levels to returning adult fish that are captured, anesthetized, handled, sampled, tagged, and released through the proposed program, the Makah Tribe proposes to implement the following conservation measures:

1) The traps in the lower and upper Ozette River will be actively operated by Makah Tribe and/or NMFS MML personnel, allowing for the selective take of migrating sockeye salmon and the free passage of the remaining 95 % of the total return.
2) Continuous monitoring of the traps when they are operated decreases the likelihood for injury and mortality to captured fish by minimizing trap live box holding time.
3) When not fishing, the traps will be left open to allow free passage of all upstream migrating fish to prevent migrational delay.
4) Net mesh size and trap picket width dimensions proposed for the research will allow for free, unobstructed upstream and downstream passage of juvenile salmonids.
5) Fish selected for sampling and tagging will be anesthetized to minimize the risk of injury during handling.
6) After sampling and tagging, anesthetized fish will be allowed to recovery in the trap live boxes for at least 15 minutes or until the fish regain equilibrium to monitor effects on handled fish and to minimize the risk of post-release mortality.
7) During the first week of the proposed project, 15 of the 115 fish captured in the lower Ozette River trap will not be anesthetized, sampled, or extensively handled, but will be tagged with plastic, individually numbered, color-coded Floy-type tags for later recapture and identification. These differentially tagged fish will be monitored as they arrive at the upper Ozette River trap location, and compared with 15 sockeye salmon collected and tagged at the same time, but anesthetized prior to handling, to evaluate the effects of the proposed capture, handling, and tagging procedures. Results of this evaluation will be used to adjust procedures applied to the remainder of the fish captured in the proposed program, as necessary, to minimize the risk of harm.
8) Acoustic/radio tag implantation procedures will follow protocols proven to be effective in reducing post-release tagging-induced fish mortality.

B. Effects on Sockeye Salmon Critical Habitat

Adult sockeye salmon trapping, tagged sockeye salmon monitoring, and harbor seal and river otter predation monitoring will occur within critical habitat designated by NMFS for Ozette Lake sockeye salmon (65 FR 7764). Temporary traps will be used in the proposed program, and no ground or vegetation alteration is planned for the installation or operation of the trapping project or for the associated monitoring actions. No construction impacts to habitat will occur. The project is not likely to affect water quality, quantity, riparian vegetation, or cover, nor will it result in the loss of spawning or rearing habitat. The live box traps and net-mesh or picket wings used to direct fish into the live boxes will be placed on top of the streambed and maintained in place in the river channel by sand-bags and by anchoring the ends of the trap to adjacent streambanks. Any structure used to retain the traps in place will be attached to fixed structures on the banks of the river (e.g., large trees), and are not likely to harm trees or other fixed stream-side structures. All structures used to trap sockeye salmon for the purposes of this study will be removed from the water after fish capture objectives have been met.

C. Effects on other Listed Species in the Action Area

The USFWS has noted the presence of bald eagle nesting territories and northern spotted owls in the vicinity of the project (USFWS 2000). Critical periods for these species are the identified nesting months; January 1 through August 15 for bald eagles and March 1 through September 30 for spotted owls. The proposed research project involves the capture, tagging, release and monitoring of sockeye salmon. The Makah Tribe proposes to place and operate temporary traps on the Ozette River during the month of June only to capture and tag sockeye salmon. Placement, operation, and removal of the traps used to collect sockeye salmon will be accomplished by hand. Increased human activity associated with these actions will be temporary, and habitat loss and significantly increased noise levels are not expected. Critical habitat for bald eagles and spotted owls will not be adversely affected. Operation of the temporary traps is not expected to lead to noise or activity levels that are detrimental to bald eagle or spotted owl nesting or foraging behavior or areas. Sockeye salmon will not be removed from the Ozette system as a result of the trapping program, which is designed as a fish capture and release study. The total sockeye run to the Ozette Lake system will still be available as a food resource for bald eagles. No other bald eagle or spotted owl prey species are expected to be affected by the sockeye salmon-directed research.

Monitoring of harbor seal, river otter, and tagged sockeye by foot and by boat on Ozette Lake may lead to periodic increased human activity and noise levels in the action area. However, the research actions are not expected to represent significant increases over baseline activity and noise levels on the Ozette River or Ozette Lake, and no adverse effects to bald eagle or spotted owl nesting locations or behavior are expected.

The proposed research program is not expected to adversely affect bald eagles or spotted owls or result in the destruction or adverse modification of their critical habitat.

V. Cumulative Effects

Cumulative effects are defined in 50 CFR 402.02 as "those effects of future State or private activities, not involving Federal activities, that are reasonably certain to occur within the action area of the Federal action subject to consultation." For the purposes of this analysis, the action area encompasses Ozette Lake and its tributaries, and the Ozette River. This area includes sockeye salmon spawning, rearing, and migration areas. Future Federal actions, including the ongoing operation of hatcheries, fisheries, and land management activities, will be reviewed through separate section 7 consultation processes. In addition, non-Federal actions that currently require authorization under section 10 of the ESA will be evaluated in section 7 consultations, pending finalization of a 4(d) rule including take prohibitions and exempted activities for Ozette Lake sockeye salmon (proposed January 3, 2000 - 65 FR 170). Therefore, these actions are not considered cumulative to the proposed action.

Factors, past and present, that have cumulatively contributed to the decline of west coast sockeye salmon, including the Ozette Lake population, were identified and evaluated in NMFS' sockeye salmon status review document (Gustafson et al. 1997). Natural environmental fluctuations have played a role in the species' recent decline in abundance. It is likely that other human-induced impacts, including incidental harvest in certain fisheries, hatchery practices, and habitat modification, have played an equally significant role in the decline of certain sockeye salmon populations. Moreover, these human-induced impacts likely have reduced the species' resiliency to such natural factors for decline as drought and poor ocean conditions (64 FR 14528). The depressed status of the population, and the cumulative effects of the above factors, were considered by NMFS in the decision to list the Ozette Lake sockeye salmon population as threatened in 1999.

NMFS considers efforts being made to protect listed species in evaluating cumulative effects. Notable efforts to protect and recover the listed population within the range of the Ozette Lake sockeye salmon ESU include the Northwest Forest Plan, the Washington Wild Stock Restoration Initiative, and the Washington Wild Salmonid Policy. A collaborative effort to develop a recovery plan for Ozette Lake sockeye salmon, including the Makah and Quileute Tribes, the National Park Service, and the Washington Department of Fish and Wildlife was initiated in 1999. The objective of the group is to determine how to increase the abundance of naturally spawning Ozette Lake sockeye salmon to historic and self-sustaining population levels. NMFS and USFWS plan to assist in this effort. The Makah Tribe, which has operated a lake supplementation and tributary reintroduction program in Ozette Lake since the early 1980's, has developed a Hatchery and Genetics Management Plan (HGMP), as part of the Makah Tribe's Ozette Lake Sockeye salmon Recovery Plan, to guide future artificial propagation and research efforts. The HGMP includes "habitat" and "hatchery" components, and associated research and biological monitoring, to increase the abundance of lake and tributary-spawning sockeye salmon and to collect scientific information that will define limiting factors to listed sockeye salmon productivity in the lake and tributaries. When Ozette Lake sockeye salmon were formally listed, NMFS acknowledged that many of the above, on-going protective efforts were likely to promote conservation of the ESU. However, NMFS determined that, because these initiatives were recent and of low to moderate scale, they were as yet inadequate to preclude ESA listing. These, and future protective efforts initiated by tribal, state, and Federal resource managers are being encouraged by NMFS to evaluate, promote, and improve efforts to conserve Ozette Lake sockeye salmon.

VI. Conclusion

NMFS has determined that, based on the available information, the proposed Ozette Lake Sockeye Salmon Predation and Spawning Population Assessment Study is not likely to jeopardize the continued existence of Ozette Lake sockeye salmon or result in the destruction or adverse modification of their designated critical habitat. This conclusion was reached because of the small proportion of the total number of migrating, listed adult sockeye salmon in the Ozette River that will be directly taken through capture, anesthetizing, handling, tagging, and release (up to 4.8 % of the estimated total migrating population of 3,000, or 145 fish), and the low incidental lethal take anticipated for the operation (less than 2 % of the 115 fish collected for the predation study (2 fish) and 3 % of the 45 fish receiving acoustic/radio tags (2-3 fish)). An additional consideration is that the proposed trapping operations are selective, and the majority of the total sockeye salmon return will not be encountered. Fish that are not tagged for the study will be allowed to pass freely upstream without handling through remotely-operated slide gates on trap live boxes. Further, all adult sockeye salmon selected for trapping will be immediately removed from the traps, anesthetized, sampled, tagged, and released after recovery immediately without additional handling. No juvenile sockeye salmon are expected to be captured through the program, and no juvenile fish mortalities or other takes are expected. Effects on listed sockeye salmon through harbor seal and otter monitoring, and tagged sockeye salmon tracking are expected to be insignificant. No adverse effects on designated critical habitat for Ozette Lake sockeye salmon are likely as a result of the project.

Given the determination that the project is not likely to jeopardize the continued existence of Ozette Lake sockeye salmon or result in the destruction or adverse modification of their designated critical habitat, no reasonable and prudent alternatives, or conservation recommendations, are required for the proposed research program.

VII. Incidental take statement

Section 9 of the ESA prohibits any taking (harass, harm, pursue, hunt, shoot, wound, kill, trap, capture, collect, or attempt to engage in any such conduct) of listed species without a specific permit or exemption. Regulations adopted under section 4(d) may do the same for threatened species. Harm is further defined to include significant habitat modification or degradation that results in death or injury to listed species by significantly impairing behavioral patterns such as breeding, feeding, and sheltering. Harass is defined as actions that create the likelihood of injuring listed species to such an extent as to significantly alter normal behavior patterns which include, but are not limited to, breeding, feeding, and sheltering. Incidental take is take of listed animal species that results from, but is not the purpose of, an otherwise lawful activity. Under the terms of section 7(b)(4) and section 7(o)(2), taking that is incidental to, and not intended as part of, the agency action is not considered prohibited taking provided that such taking is in compliance with the terms and conditions of this incidental take statement.

The terms and conditions described below are non-discretionary, and must be implemented by the action agency so that they become binding conditions of any grant or permit issued to the applicant, as appropriate, in order for the exemption in section 7(o)(2) to apply. The Makah Tribe, acting as the lead agency under the authority of the Bureau of Indian Affairs has a continuing duty to regulate the activity covered in this incidental take statement. If the Makah Tribe (1) fails to adhere to the terms and conditions of the incidental take statement through enforceable terms that are added to the permit or grant document, or (2) fails to retain the oversight to ensure compliance with these terms and conditions, the protective coverage of section 7(o)(2) may lapse.

An incidental take statement specifies the impact of any incidental taking of endangered or threatened species. It also provides reasonable and prudent measures that are necessary to minimize impacts and sets forth terms and conditions with which the action agencies must comply in order to implement the reasonable and prudent measures.

A. Amount or Extent of Take Anticipated

As indicated in this Opinion, listed Puget Sound/Washington Coastal Dolly Varden/Bull trout are not likely to be incidentally taken through the proposed trapping in the Ozette River or through monitoring activities in Ozette Lake. The Ozette River Basin does not harbor a Dolly Varden/Bull trout population (Gustafson et al 1997; WDFW 1999), and the USFWS does not include Dolly Varden/Bull trout on its "Species List" designating ESA-listed and sensitive populations requiring consideration in the Ozette Lake action area (USFWS 2000; J. Chan, USFWS, pers. comm.). The proposed research project will therefore have no effect on listed bull trout, nor jeopardize the continued existence of the Puget Sound/Washington Coastal distinct population segment of Dolly Varden/Bull trout or result in the destruction or adverse modification of their designated critical habitat.

No other ESA-listed salmonid populations are likely to be affected by the research program.

Listed bald eagles and spotted owls identified by USFWS as present in the vicinity of the proposed research may be encountered, but are not likely to be adversely affected by the trapping, tagging, and monitoring research. The research program involves placement and operation of temporary traps over a limited period (June), and periodic, short duration monitoring by foot and boat. These actions should not pose significant risks to bald eagle and spotted owl nesting or foraging resources or behavior. The proposed research project will therefore not adversely effect listed bald eagles or spotted owls, nor jeopardize their continued existence or result in the destruction or adverse modification of their designated critical habitat.

In the accompanying Opinion, NMFS determined that the anticipated levels of take of up to 145 individual, listed adult Ozette Lake sockeye salmon for predation assessment and survey research purposes is not likely to result in jeopardy to the species or destruction or adverse modification of critical habitat.

B. Reasonable and Prudent Measures

NMFS believes that the amount of take of Ozette Lake sockeye salmon that could occur as a result of the actions evaluated in this Opinion has been adequately minimized by the study design. Therefore reasonable and prudent measures to further reduce this incidental take are not necessary. However, the action agencies shall report (as stipulated below in the Terms and Conditions section) all ESA-listed fish that are encountered.

C. Terms and Conditions

In order to be exempt from the prohibitions of section 9 of the ESA, the Makah Tribe must comply with the following terms and conditions, which state the required reporting and monitoring requirements. These terms and conditions also detail the conditions of the research. These terms and conditions are non-discretionary.

1. The total number of ESA-listed adult sockeye salmon that may be captured, handled, anesthetized, externally tagged, released, then recaptured for sampling and examination

through that portion of the research program directed primarily toward assessment of the effects of harbor seal and otter predation shall not exceed 115 fish, or 3.8 % of the total estimated return of 3,000 fish to the Ozette River Basin in 2000.

2. The total number of ESA-listed adult sockeye salmon that may be captured, handled, anesthetized, tagged with a combined acoustic/radio tag, and released through that portion of the research program directed towards the pilot assessment of sockeye salmon migration, and lake holding, spawning distribution and behavior shall not exceed 45 fish, or 1.5 % of the total estimated return of 3,000 fish to the Ozette River Basin in 2000.

3. The total number of ESA-listed adult sockeye salmon that are directly observed to be lethally taken incidental to the above trapping and tagging programs shall not exceed 6 fish, or 4.1 % of the total number of ESA-listed sockeye salmon captured and handled through the trapping program. Monitoring is required to determine if mortality rates are higher than expected for sockeye salmon receiving surgically implanted tags.

4. To effect the proposed trapping programs, the traps shall be actively operated, and continuously monitored by Makah tribal or NMFS MML personnel to minimize the risk of harm to listed sockeye salmon and to minimize incidental take effects to the sockeye salmon run at large. When not operating, the net-mesh weir in the lower Ozette River, and the fish counting weir in the upper Ozette River, shall be maintained in open positions to allow free passage of upstream- and downstream-migrating fish.

5. When the traps are actively operating, sockeye salmon not selected for use in the proposed capture and tagging programs, and all other fish species encountered, shall be allowed to pass immediately, without handling, through the lower and upper Ozette River traps.

6. The trapping locations shall be monitored 24 hours per day to determine whether sockeye salmon migration is significantly delayed, or if the operations, including fish handling and tagging, are leading to increased predation opportunities by harbor seals or river otters. The traps shall be opened to allow unobstructed fish passage if significant numbers of sockeye salmon are observed to be delaying migration immediately downstream of the traps, or if the sites are observed to be increasing short term predation opportunities.

7. Adult sockeye salmon retained for the program shall be selected from the run at large using a randomized protocol. Fish selected must be handled with extreme care and kept in water to the maximum extent possible, with the amount of time required to remove fish from the trap live boxes for sampling and tagging minimized to the extent feasible.

8. A healthy environment for all sockeye salmon adults must be provided during capture, holding, anesthetization, sampling, and tagging to minimize harm to the fish. Water to water transfers, the use of shaded, dark containers and supplemental oxygen must all be considered in designing fish handling operations. Crew-members who are experienced in holding and processing stressed fish are necessary to ensure that anesthetization,

sampling, and tagging procedures are conducted in a risk averse manner.

9. Trapping must cease and sockeye salmon adults must not be handled if the water temperature exceeds 70 degrees Fahrenheit at the Ozette River trapping sites.

10. Adult sockeye salmon removed from the Ozette River for sampling and tagging shall be anesthetized using practices and drug concentrations recommended for the use of MS 222 by the Pacific Northwest Fish Health Protection Committee (1989) or clove oil to minimize the likelihood for over-dosage and mortality. Concentrations of MS-222 and clove oil will be carefully measured and tested prior to pre- and full anesthetization. Fish examination and recovery processes shall be conducted to guard against overexposure of adult sockeye salmon to these anesthetics.

11. After the adult sockeye salmon have been processed, the fish shall be transferred immediately to the trap live boxes for recovery. The recovering fish shall be monitored to ensure that the effects of the anesthetics are no longer evident prior to the volitional, upstream release of the fish from the trap live boxes.

12. If the take levels authorized here are exceeded, or if circumstances indicate that such an event is imminent, the Makah Tribe must notify NMFS' Protected Resources Division as soon as possible, but no later than two days after the authorized level of take is exceeded.

13. If the forecasted run size on which the above authorized take proportions of the total run are based appears inseason to be substantially lower than 3,000 adult sockeye salmon (less than 2,000 fish), the Makah Tribe must notify NMFS' Protected Resources Division as soon as possible to discuss potential down-scaling of fish capture levels.

14. The Makah Tribe shall provide NMFS' Sustainable Fisheries Division weekly updates of the estimated abundance status of the 2000 sockeye return. The Makah Tribe shall also notify the Sustainable Fisheries Division by June 12 regarding the results of trapping and tagging during the first week of operation, and plans to modify handling protocols if observed sockeye salmon injury or mortality rates are above expected levels.

15. The Makah Tribe shall provide NMFS' Protected Resources Division with documentation of the activities authorized in this Opinion. The report must include a detailed description of the activities, the total number of adult sockeye salmon trapped and released at the trapping locations, the manner of take, the dates and locations of take, the number of mortalities (if any), and the condition of all fish released. The annual report must also include the results of monitoring and research, and a description of the degree to which the program's goals were met. The annual report is due by January 31, 2000.

16. The annual report and notification of unauthorized take must be made to:

    Chief, Protected Resources Division
    National Marine Fisheries Service

525 NE Oregon St., Suite 500
Portland, OR 97232-2737
phone (503) 230-5400
fax (503) 230-5435

VIII. Reinitiation of Consultation

Reinitiation of consultation is required if: (1) the amount or extent of taking specified in the incidental take statement, above, is exceeded, (2) the action is modified in a way that causes an effect on the listed species that was not previously considered in this Opinion, (3) new information or project monitoring reveals effects of the action that may affect listed species in a way not previously considered, or (4) a new species is listed or critical habitat is designated that may be affected by the action (50 CFR section 402.16). Furthermore, finalization of take prohibitions for Ozette Lake sockeye salmon may cause this consultation to be reinitiated if new information reveals effects of the action(s) that may affect the ESA-listed species in a way that is not considered in this consultation or the action(s) is modified in a way that causes an effect on the ESA-listed species that is not considered in this consultation.

IX. References

Beauchamp, D.A., M.G. LaRiviere, and G.L. Thomas. 1995. Evaluation of competition and predation as limits to juvenile kokanee and sockeye salmon production in Ozette Lake, Washington. North American Journal of Fish Management. 15:193-207.

Beddow, T.A., C. Deary, and R.S. McKinley. 1998. Migratory and reproductive activity of radio tagged Arctic char (Salvelinus alpinus L.) In northern Labrador. Hydrobilogia 371/372: 249-262.

Dlugokenski, C.E., W.H. Bradshaw, and S.R. Hager. 1981. An investigation of the limiting factors to Ozette Lake sockeye salmon production and a plan for their restoration. U.S. Fish and Wildlife Service, Fisheries Assistance Office, Olympia, WA. 52 p.

Federal Register Notice (64 FR 14528). 1999. Final Rule - Endangered and Threatened Species: Threatened Status for Ozette Lake Sockeye Salmon in Washington. Effective date - May 24, 1999. 50 CFR Part 223. Federal Register, March 25, 1999.

Federal Register Notice (65 FR 170). 2000. Proposed Rule - Endangered and Threatened Species; Proposed Rule Governing Take of Seven Threatened Evolutionarily Significant Units (ESUs). 50 CFR Part 223. Federal Register, January 3, 2000.

Federal Register Notice (65 FR 7764). 2000. Final Rule - Designated Critical Habitat: Critical Habitat for 19 Evolutionarily Significant Units of Salmon and Steelhead in Washington, Oregon, Idaho, and California. 50 CFR Part 226. Federal Register, February 16, 2000.

Gearin, P.J., L.L. Lehman, K.M. Hughes, L. Cooke, R.L. Delong, and M.E. Gosho. 1998. Investigations of pinniped interactions with Lake Ozette sockeye salmon, Oncorhynchus nerka, 1998. U.S. Dept. Commer., NOAA, National Marine Mammal Laboratory, Alaska Fisheries Science Center, Seattle, WA., and Makah Fisheries Management, Neah Bay, WA. Unpublished report. 33 pp.

Gustafson, R.G. 1999. Draft position paper on introduction of sockeye salmon into Ozette Lake tributaries. Northwest Fisheries Science Center, National Marine Fisheries Service. U.S. Dept. Commer., Seattle, WA.

Gustafson, R.G., T.C. Wainwright, G.A. Winans, F.W. Waknitz, L.T. Parker, and R.S.Waples. 1997. Status review of sockeye salmon from Washington and Oregon. U.S. Dept. Commer., NOAA Tech. Memo. NMFS-NWFSC-33, 282 p.

Makah Tribe. 2000. Draft hatchery and genetic management plan. Ozette Lake sockeye salmon artificial propagation, research, and biological programs. Fisheries Management Department, Makah Tribe. Neah Bay, WA.

Makah Tribe and National Marine Fisheries Service Marine Mammal Lab (NMFS MML). 2000. Predation assessment, capture, tagging, and survey of adult Ozette Lake sockeye. Fisheries Management Department, Makah Tribe. Neah Bay, WA.

National Marine Fisheries Service (NMFS). 1997. Investigation of scientific information on the impacts of California sea lions and Pacific harbor seals on salmonids and on the coastal ecosystems of Washington, Oregon, and California. U.S. Department of Commerce, NOAA Technical Memorandum NMFS-NWFSC-28. 172 p.

Pacific Northwest Fish Health Protection Committee. 1989. Model comprehensive fish health protection program. 19 pp.

U.S. Fish and Wildlife Service (USFWS). 2000. Listed and proposed endangered and threatened species, candidate species and species of concern which may occur within the vicinity of the proposed predation assessment, capture, tagging, and survey of adult Lake Ozette sockeye project in Clallam County, Washington. “Species List” for T31N R16W S24. May 11, 2000. U.S. Department of Interior, Fish and Wildlife Service, North Pacific Coast Ecoregion. Lacey, WA.

Washington State Department of Fish and Wildlife (WDFW). 1999. 1998 Washington salmonid stock inventory: Appendix bull trout and Dolly Varden. Fish Program, Washington Department of Fish and Wildlife. Olympia, WA.

Washington Department of Fisheries (WDF) and Western Washington Treaty Indian Tribes (WWTIT). 1994. 1992 Washington State salmon and steelhead stock inventory (SASSI). Appendix Two, Coastal stocks. Washington Dept. Fish Wildlife., 588 pp.

Attachment 2. Characterization of Lake Ozette Sockeye Using Genetic and Otolith Marks.

1. Summary and Authorization

Project Title: Characterization of Lake Ozette Sockeye Salmon for Enhancement Recovery Strategies Using Genetic and Otolith Marks.

Desired Project Period From: 3/31/2000 To: 3/31/2002

Total Requested Funds: $ 92,250 Matching funds available: $45,920

The Scientific Review Team is requested to consider the following research preproposal for financial assistance. We agree to cooperate with the Team and IAC by furnishing such additional information as may be necessary to execute an IAC Project Agreement and to adhere to all appropriate state and federal statutes governing grant monies under the Project Agreement. We are aware that the grant, if approved, is paid on a reimbursement basis.

I/we certify that to the best of our knowledge, the data in this application is true and correct. In addition, I/we certify that the matching resources identified in the grant are committed to the above project. I/we acknowledge responsibility for supporting all non-cash commitments and donations should they not materialize.

Authorized Representative:

(signature) *(date)*

Printed Name and Title: David B. Sones, Natural Resources Director

Organization: Makah Fisheries Management, Makah Tribal Council

2. Proposal/Project Contact Person

(Who is the project's primary investigator, and how do we communicate with that person?)

Last Name: Crewson
First Name: Michael

Title: Salmon Division Manager
Email: coho@olypen.com

Organization: Makah Fisheries Management

Address: P.O. Box 115
Work Phone: (360) 645-3168

City/Town: Neah Bay
Cell phone: (360) 640-0381

State, Zip: WA, 98357
FAX: (360) 645-2323

3. Applicant / Organization Information **(For the organization which seeks funding)**	
Organization Name: Makah Tribal Council, Fisheries Management Department	
Organization Address: Makah Fisheries Management Address: P.O. Box 115 City/Town: Neah Bay County: Clallam State, Zip: WA 98357 TEL: (360) 645-3168 FAX: (360) 645-2323 E-mail: coho@olypen.com	**Billing Information:** Payee Name: Makah Tribal Council Accounting official: Bob Polasky, General Manager Address: P.O. Box 115 City/Town: Neah Bay State, Zip: WA 98357 TEL: (360) 645-3122 FAX: (360) 645-2127 Email: mtcgm22@olypen.com

4. Project Location Information **(WRIA refers to the state Water Resources Inventory Area)**	
Site Name or Hatchery Name: Umbrella Creek Hatchery, Makah National Fish Hatchery, Educket Creek Hatchery	
Waterbodies Impacted (include main river/tributaries and marine habitats) Lake Ozette Basin, include Ozette River, Lake Ozette, Umbrella Creek, Big River, and other tributaries.	
Counties: Clallam	
City/Town (if applicable): NA	
WRIA Number 20	WRIA Name: Quillayute-Hoh

6. Project Abstract

This project provides baseline genetic and demographic information for testing 1) whether sockeye salmon can be successfully reintroduced into tributaries of Lake Ozette, where they were extinct, and 2) whether distribution and abundance of beach spawning aggregations can be rebuilt through supplementation. Genetic profiles of Lake Ozette sockeye salmon, which are protected under the ESA, and kokanee salmon, which are not, are necessary to guide brood stock selection and to monitor hybridization and gene flow. Profiles will be developed from 6-8 microsatellite DNA loci. The ability to mark and identify hatchery is also essential to monitor recovery efforts, but some of the hatchery-produced sockeye salmon will be released before external markings are possible. Consequently, this project tests otolith marking as a tool. The combination of genetic data and otolith marking will allow the co-managers to develop effective strategies to monitor abundance, distribution, and interactions among natural and hatchery aggregations. Project results will be summarized in a final technical report to the funding agency, co-managers, and National Marine Fisheries service MFS and will be incorporated into the Hatchery Genetic Management Plan, the Lake Ozette Sockeye Recovery Plan, and the Makah Tribal Resource Management Plan.

7. Project Description

1. **Project title:** Characterization of Lake Ozette Sockeye Salmon for Enhancement Recovery Strategies Using Genetic and Otolith Marks.

2. **Principal Investigator(s):** Dr. Kenneth P. Currens, Northwest Indian Fisheries Commission
Dr. Jim Shaklee, Washington Department of Fish and Wildlife
Michael Crewson, Makah Fisheries Management.

3. **Associate Investigator(s)**: Jeffrey J. Grimm, Washington Department of Fish and Wildlife

4. **Project Goal**: The goal of this project is to develop baseline genetic information and demographic monitoring tools that can be use to test 1) whether sockeye salmon can be successfully reintroduced into tributaries of Lake Ozette, where they were extinct, and 2) whether distribution and abundance of beach spawning aggregations can be rebuilt through supplementation. The results of this research will be incorporated into the Lake Ozette Sockeye Hatchery Genetic Management Plan and will provide a key component in the adaptive management strategy for recovering Lake Ozette sockeye salmon.

3. Objectives:

Objective 1: Test the hypothesis that the two major beach spawning aggregations on Olsen's Beach and Allen's Bay are the same population using microsatellite DNA loci.
Objective 2: Identify genetic markers that could be used to monitor potential hybridization between sockeye and kokanee salmon.
Objective 3: Evaluate otolith marking as a tool to estimate reproductive success, survival, age composition, and distribution of hatchery fish.
Objective 4: Communicate results.
Objective 5: Implement hatchery reform through adaptive management.

4. Study design and methods:

Objective 1: We will describe the genetic variation of sockeye salmon spawning on Olsen's Beach and Allen's Bay at 6-8 microsatellite loci over at least two generations. Microsatellite loci have been shown to be useful in identifying local differences among stocks (Beacham *et al.* 1998). We have tentatively identified *Omy-77, Ots-3, Ots-100, Ots-103, Ots-107,* and *Ots-108* as appropriate loci (Beacham and Wood 1999). Primers for other loci identified in other Pacific salmon may be also be used. Tissue from 50-100 individuals will be taken from archived samples, carcasses on the spawning grounds, or as non-lethal fin clippings from live fish in a manner that will minimize stress to the fish. Washington Department of Fish and Wildlife (WDFW) and the Makah Tribe have archived samples from 1998 and 1999 brood years, respectively. We will collect additional samples from the 2000/2001 brood year. Laboratory work will be done by the WDFW genetics laboratory under the supervision of Dr. Jim Shaklee. DNA will be extracted using an inorganic extraction protocol, and the microsatellite loci isolated and amplified using polymerase chain reaction (PCR). Primers will be labeled using phosphoramidite fluorescent dye to be able to detect DNA fragments on a Perkin-Elmer, Applied Biosystems 377 semiautomated DNA sequencer. We will use ABI GeneScan and Genotyper to read the raw data and assign genotypes. Data will be examined using exact tests for Hardy-Weinberg equilibrium, genotypic linkage disequilibrium, and genic and genotypic differentiation.

Objective 2: We will describe the genetic variation in 50 individuals from six different tributary streams containing kokanee salmon. These will include two streams where reintroduction of sockeye salmon is proposed and four tributaries where kokanee are abundant but no reintroduction is proposed. Samples will be collected in 2000/2001 by Makah Fisheries Management. Laboratory procedures and analyses will be as described in Objective 1. In addition, genotypes will be examined for potential genetic marks between sockeye and kokanee salmon and probabilities of detecting gene flow will be analyzed by simulation.

Objective 3: Otoliths of artificially propagated sockeye salmon incubating at the Educket Hatchery (2000) or Makah National Fish Hatchery (2001) with be uniquely marked by manipulating water temperatures. Temperatures of eyed eggs will be manipulated by moving trays of eggs between Heath/FAL stacks supplied with heated or ambient temperature water. Water will be heated by passing it through two 220 volt, 6000-watt stainless steel water heaters attached to a single Heath/FAL stack. A rapid 3^{o}C drop in temperature is expected to disrupt otolith growth and produce a dark ring in the otolith microstructure. By implementing a different sequence of temperature changes for each treatment group, we will induce a unique, permanent pattern in the microstructural of the otoliths before the fish are released. A sample of 20 individuals will be archived from each treatment group to establish a reference pattern. In addition, otoliths from 180 spawners collected during the genetic sampling and brood stock collecting will be examined to provide baseline data on growth, age, and migration. Each sample will include a unique sample number, sample date, and sample location.

To identify patterns, sagittal otoliths will be dissected from the fish. Otoliths will be mounted, sectioned, lapped, and polished until the microstructure of each is clearly visible. The prepared otolith will be examined independently with a compound microscope at 200x and/or 400x magnification by two different otolith to determine the pattern. Hatchery fish returning in 2004 and 2005 will be identified to treatment group by comparing their otolith banding pattern to the archived reference pattern. Money for this analysis will be sought later. Once the patterns have been identified and compiled, the data will be analyzed to evaluate the effect of different release treatments on growth, survival, stray rates, and age composition.

Background and Rationale:

The Makah Tribe is developing a long-term strategy for how to use artificial propagation to rebuild and recover anadromous Lake Ozette sockeye salmon. Details of the hatchery facilities, operational protocols, performance standards, and risk analysis will be available in the Lake Ozette Sockeye Hatchery Genetic Management Plan Section 7 Biological Assessment. The strategy, however, has two targets: (1) reintroducing sockeye salmon to the tributaries of Lake Ozette, where they were extirpated and (2) rebuilding beach spawning aggregations, which are listed as threatened under the ESA. Current hatchery activities are focused only on reintroduction to the tributaries. Supplementation of beach spawning aggregations is contingent on determining the factors that are limiting the abundance and distribution along the lake, whether the limiting life history stages can be addressed by artificial production, and identifying the genetic population structure among aggregations.

Reintroduction of sockeye salmon to the tributaries is a unique opportunity to test whether it is possible to restore not only the abundance but also the spatial structure and diversity of declining spawning aggregations. Rebuilt abundance, spatial structure, productivity, and diversity are indicators of population viability and are a major part of the National Marine Fisheries Service's goal for recovery of salmon (McElhany *et al*. 1999; FR 65(1):170-196). Accomplishing this presents enormous evolutionary and management challenges that have not been well studied. Most research has been focused on the success or risks of artificial production in rebuilding or maintain existing populations rather than on the success of reintroduction of extirpated populations within a threatened metapopulation or evolutionarily significant unit (ESU).

Lake Ozette is especially suited for this kind of experiment. The population structure of the ESU is simple and contained within a relatively small geographical scale. Many of the problems facing the ESU (degradation of habitat and introduction of exotic plants and animals) are common to other threatened metapopulations. Unlike many areas where supplementation is being studied, however, the results in Lake Ozette will not be confounded by mortality at hydroelectric dams or harvest. No harvest has occurred in since 1984, and in the 10 years before that ceremonial and cultural harvest averaged 25 fish per year.

The results from this hatchery experiment in reintroduction could be valuable in other areas. Sockeye salmon and coho salmon have been extirpated from major areas of the Columbia River. Unique life history races of salmon, such spring chinook, have disappeared from many streams within the Puget Sound, leaving only a few remnant populations within the ESU. The future removal of barrier dams, such on the Elwha River, is raising questions of whether it is possible to devise an appropriate artificial production strategy for reintroducing anadromous salmonids to areas where they have been extirpated. In addition, an understanding of how rapidly salmon can adapt and diversify could have major implications for Puget Sound chinook salmon in areas lacking indigenous populations, such as the Puyallup, Nisqually, and Skokomish rivers.

Ecological and Genetic Characteristics Lake Ozette is a unique lake with an evolutionarily distinct group of sockeye salmon (*Oncorhynchus nerka*). Located in the isolated northwest corner of Washington, the lake occupies 2,954 ha in the middle of a once lush Olympic rainforest community. The lake is fed by numerous low-to-moderate gradient ephemeral and perennial streams and is drained by the Ozette River 8 km into the Pacific Ocean. Intensive road building and clear-cut logging of Sitka spruce (*Picea sitchensis*) and western hemlock (*Tsuga heterophylla*), which once dominated the Lake Ozette watershed, have reduced most of the forest and riparian areas to early successional stands of red alder (*Alnus rubra*) and mixed conifers, is thought to have buried spawning gravels in streams and beaches under increased silt loads and is also presumed to have increased the incidense and intensity of run off contributing to high flows that can destroy salmon redds. Introduction of non-native predators, such as yellow perch (*Perca flavescens*) and largemouth bass (*Micropterus salmoides*) and invasion of reed canary grass (*Phalaris arundinacea*), which is rooting along the tributaries and spawning beaches, have also changed the community (Jacobs *et al.* 1996).

Two distinct groups of Oncorhynchus nerka existed in Lake Ozette. Anadromous stream- and lake-spawning sockeye salmon and kokanee salmon (a freshwater resident life history form). The stream-spawning, anadromous life history form is thought to have been extirpated from the tributaries during this century, while lake-spawning sockeye salmon are thought to be limited to two spawning beaches (Olsen's Beach and Allen's Bay Beach). Kokanee occupied many of the tributaries and have remained abundant in the smaller tributaries although very few can be found in Umbrella Creek and Big River, the largest drainages in the Basin. Anadromous sockeye salmon are believed to have spawned in several tributaries and along lake beaches. The historical abundance of these sockeye is poorly documented. In the first study of lake escapement of Ozette sockeye (Kemmerich 1945), the run size entering the lake was estimated at a level of several thousand fish. These counts are assumed to have been conducted upstream from fisheries in or near to the Ozette River. Verbal reports from fish buyers of sockeye harvested by the Makah Tribe purportedly ranged from 14,556 to 17,638 fish during a three-year period from 1949 to 1951. These catches were assumed to be from the Ozette River as reported by Dlugokenski *et al*. (1981) and later in Jacobs *et al*. (1996); however, there were and are no written fish tickets or other records of these harvests (Jeff Haymes, WDFW, personal communication).

While catches reported from the Makah Tribe declined from several thousand sockeye to less than 100 fish within the following 20 years, these three large catches appear disproportionately large relative to any other years recorded. During this same period, large catches of Lake Quinault sockeye averaging approximately 120,000 fish, were reported from the Quinault River, located to the south of the Ozette River, as reported by Ward *et al*. (1976) and Gilbertson (1981) In Jacobs *et al*. (1996). Dlugokenski *et al.* (1981), reported that, "catch data from 1948 through 1972 is extremely unreliable and is presented here primarily to illustrate a general decline in harvest." While it may not be reliable to use these verbal catch reports from fish buyers as a measure of historic abundance, there remains a significant decline in catch beginning in the 1950's and a significant decline in run size since the work of Kemmerich (1945).

Extant lake spawning aggregations were shown to be a genetically distinct evolutionarily significant unit (ESU) based on allozyme analyses (Winans *et al*. 1996, Gustafson *et al*. 1997) and were protected under the ESA. They were most similar to populations in the Nooksack, Sauk, and Skagit rivers and Babine Lake. Lake Ozette kokanee salmon, however, were different from Lake Ozette anadromous sockeye salmon and all other populations of sockeye or kokanee salmon examined, suggesting strong reproductive isolation and evolutionary divergence. They were not included in the ESU.

Within the ESU, the two known beach spawning aggregations are currently treated as separate populations, but scientific support for this is inconclusive. The National Marine Fisheries Service noted significant differences in allozyme frequencies between spawners from the two locations (Gustafson et al. 1997). Significant differences between samples from the same location in different years, however, also suggested that presumed geographical differences were actually temporal variations in the same population.

Recently, a third aggregation of anadromous sockeye salmon has emerged as part of the ESU. Evidence indicates that the release of fry derived from lake spawners into Umbrella Creek appears to have resulted in a self-sustaining run in that tributary. In 1996, 101 sockeye salmon spawned in Umbrella Creek as descendants of this release. This is known because 99% of sockeye salmon in Lake Ozette were four-year-olds and no hatchery fish were released in 1992. Therefore fish spawning in Umbrella Creek in 1996 were of natural origin. In 1999-2000, the estimated number of sockeye spawning in the creek was 400 of which approximate 149 were of natural origin. The number of natural origin fish per mile of stream increased from 19 to 52 (unpublished data).

The apparent success of sockeye salmon in Umbrella Creek conflicts with suggestions in the scientific literature that lake spawning sockeye salmon may face large challenges in colonizing and adapting to the stream environment. Stream spawning stocks may have unique physiological adaptations for surviving in streams and migrating to the sea, such as larger eggs, the ability to tolerate higher level of fine sediment, fast growth, rapid seawater adaptability, and increased propensity for straying (Lorenz and Eiler 1989, Rice *et al.* 1994, Wood 1995). With the exception of the Fraser River, stream spawning sockeye salmon were also rare south of the Stikine River. Lack of stream spawners in these areas may have been due to 1) insufficient colonists from northern areas with the genetic capacity for adapting the necessary life history; 2) lack of suitable habitat; or 3) small, unique stream spawning stocks (such as the Ozette stocks) that were overlooked or extirpated before extensive surveys began (Halupka *et al*. 1993). Whether the appearance of sockeye salmon in Umbrella Creek was a fortuitous example of founder effect and rapid selection following Wright's shifting balance theory of evolution (Wright 1931) or the lake spawners already had the necessary adaptations is unclear.

Artificial Production Strategy
The apparent success of these fish in Umbrella Creek suggests that sockeye salmon derived from native lake spawners may be capable of reestablishing in Lake Ozette tributaries, despite the enormous evolutionary and ecological challenges. Reintroduction may be able to exploit the success of Umbrella Creek fish. The basic strategy for reintroduction is to use sockeye salmon returning to Umbrella Creek from throughout the run as the source of brood stock. Approximately 40 pairs of males and females will be used for brood stock initially. Matings will be based on a 4 x 4 factorial design to maximize genetic effective population size, including natural origin fishes. Fish may be introduced as (1) eyed eggs, (2) unfed fry, or (3) fed fry and fingerlings. To test the success of these different treatments, all fish will need to be differently marked as eyed eggs. Consequently, evaluating the success of otolith marking is essential to this strategy. All fish released at a weight greater than 0.5 gm will also have the adipose fin clipped. Sockeye will be reintroduced only into streams that lack abundant kokanee and that have suitable habitat. Monitoring plans call for evaluating potential hybridization with kokanee salmon and changes in the life history of the fish. The current program is slated for 12 years or three generations (2000 to 2012) before reevaluation.

Risk Assessment and Risk Management
Despite the apparent value of artificial propagation as a conservation tool (see reviews in Olney *et al.* 1994), it does pose genetic and ecological risks in salmon (Hindar *et al*. 1991, Waples 1991, Busack and Currens 1995, Campton 1995, Waples 1995, Allendorf and Waples 1996). These risks for Lake Ozette are described below. The major purpose this research is to provide the baseline information that will allow the Makah Tribe to address these risks and design a program to test whether reintroduction can be successful.
Loss of Among-Population Diversity. The two major sources of loss of among-population diversity are (a) potential hybridization of kokanee and sockeye salmon and (b) straying of returning Umbrella Creek fish to lake spawning aggregations. The likelihood of these happening is low, but vulnerability (see Currens and Busack 1995 for discussion of terms) is considered high because of the potential consequences. Culture and release of Umbrella Creek fish may disrupt the natural reproductive isolating mechanisms that have kept lake spawners and kokanee or different spawning aggregations of lake spawners distinct. This could result in poor performance resulting from outbreeding depression for crucial life history traits. For example, although kokanee salmon in other areas have displayed migratory characteristics where saltwater was available (Chapman 1941, Foerster 1947, Rounsefell 1958, Fulton and Pearson 1981), kokanee populations in other areas, including Lake Ozette and Lake Cowichan, do not (Dlugokenski et al. 1981, Rutherford et al. 1988). Limiting sockeye reintroductions to Umbrella Creek and Big River, which have no spawning populations or very small numbers of kokanee, reduces this risk. Also, no straying of tributary returning, hatchery-origin, adults to the lake beaches (0/121 of lake spawners sampled were adipose clipped) was observed in the 1999 return, which is the only return year where marked hatchery-origin returning adults were monitored in the lake spawning aggregations after a tributary release. The baseline genetic information needed to determine whether lake spawning aggregations are really different and to design a monitoring plan for these risks is requested in this proposal.

3. *Loss of Within-Population Diversity*. Use of returning Umbrella Creek hatchery fish for reintroduction

limits the potential brood stock mining of wild lake spawning aggregations and any effects that may have on reducing the effective population size. The estimated composite hatchery-wild genetic effective population size is 1,750 (range 436-3,064, Currens unpubished data), suggesting that loss of within-population diversity is unlikely to be a major concern in the ESU in short or moderate duration programs. If naturally produced sockeye salmon returning to Umbrella Creek represent an evolving subpopulation, it is possible that supportitive breeding could reduce the effective population size of this subpopulation. It seems likely that Umbrella Creek fish may already have undergone a significant founder effect. A marking systems that will allow the Makah Tribe to distinguish hatchery from naturally produced fish is a key component in managing this risk. In addition, the genetic data need to test for possible differentiation and to examine changes in genetic diversity are a part of this proposal.

4. *Domestication.* Overall vulnerability to domestication is low to moderate depending on the strategy. The best available strategy for limiting domestication is to limit the time spent in an artificial environment and to minimize the use of hatchery origin fish in the brood stock. Overall, the duration and intensity of culture of Ozette sockeye has been very minimal compared to artificial production of other species. The artificial production strategy proposes three treatments that vary in the intensity and duration of culture ranging from release of eyed eggs to release of fed fry. Release of eyed eggs is required for reintroduction strategies to allow for imprinting to their new release environment. Monitoring has suggested that flow conditions in spring and life history of unfed fry may be more conducive to outmigration while fed fry or fingerlings may survive at a higher rate once in the lake. Survival of feed fry and fingerlings will be compared to that of unfed fry, which can only be otolith marked.

   The test of otolith marking proposed in the research is essential for determining the relative success of different treatments. This is necessary to make wise choices about the trade-offs. In addition, the otolith survey of existing *O. nerka* spawning aggregations will provide baseline life history information that may be useful in assessing the potential changes in the behavior or demographics of hatchery fish, which might indicate domestication effects.

5. *Predation and Competition.* Vulnerability to predation and competition from hatchery introductions is low. In all tributaries, except Umbrella Creek, there are no natural anadromous sockeye to compete with or prey on. In Umbrella Creek, interactions on the spawning grounds and population dynamics of the natural and wild fish will be monitored to determine whether the abundance of hatchery fish is having a significant density dependent impact on natural origin recruits. Competition and predation between kokanee and anadromous sockeye salmon in the streams is minimized by limiting reintroduction to streams where kokanee are rare or absent. Juvenile sockeye salmon and kokanee migrate to the pelagic zone of the lake to rear soon after emergence (Jacobs et al. 1996), reducing other potential ecological interactions in the streams.

   During residence in the lake kokanee, naturally produced sockeye, and hatchery produced sockeye feed primarily on *Daphnia pulicaria*, but competition is assumed to be minimal. Bioenergetic simulations (Beauchamp *et al*. 1995), size of smolts (Dlugokenski *et al*. 1981), and production of zooplankton in Lake Ozette (Bortleson and Dion 1979) all indicate that food supplies in the lake are not limiting.

6. *Catastrophic Failure in the Hatchery*. Incubation facilities at Umbrella Creek have been based on a low technology approach, because of the isolation and small scale of the program. This raises the potential for catastrophic losses in the hatchery. To help reduce this risk, the Umbrella Creek facility will be used for holding brood stock before spawning and the Educket Hatchery, where disease and facility problems can immediately detected and corrected, will be used for egg incubations. Long-term plans call for eggs to be incubated at Makah National Fish Hatchery, after the construction of a new isoincubation facility.

5. Partnership Groups:

Northwest Indian Fisheries Commission

Washington Department of Fish and Wildlife

6. Anticipated outcomes/benefits:

Objective 1: The results from this study will help clarify the population structure of Lake Ozette sockeye salmon. The study design is intended to provide a test of potential variation between spawning areas, between years, and between generations (a large majority of these sockeye are four-year-olds). Whether the two spawning aggregations are one or two populations directly effects how wild brood stock will be collected, spawned, and released into the lake in the future and the relative risks of brood stock collection. If they are the same population, the risk of collecting spawners from Allen's Bay (a relatively small spawning aggregation) can be reduced by collecting from the more abundant aggregation at Olsen's Beach, and by combining collections. If they are different, very different strategies need to be considered. These results and their management implications will immediately be evaluated and incorporated into the hatchery management plans required for Section 7 consultations and 4(d) plans under ESA. Results will be summarized in annual and final reports.

Objective 2: The results of this study will help clarify the population structure among kokanee salmon within Lake Ozette. In addition, the results will help the Makah Tribe design a monitoring program for potential hybridization of kokanee and sockeye salmon. This monitoring program is an essential part of the Hatchery Genetic Management Plan for artificial production in Lake Ozette required under 4(d) rule exemptions of the ESA.

Objective 3: The results of this objective will allow us to determine whether otolith marking can be used to mark and identify different treatment groups. The ability to identify experimental fish identify fish by origin is crucial to measuring changes in reproductive success, survival, age composition, and distribution of hatchery fish and natural sockeye salmon and appropriately modifying the hatchery program in the future. Results will also be incorporated into hatchery management plans and decisions required for Section 7 and 4(d) compliance under ESA.

Objective 4: Communication of the findings will provide scientists, fishery managers, and the public with access to data and an understanding of how science is being incorporated directly into hatchery management and reform.

Objective 5: The anticipated outcome of this objective is more effective hatchery operations that reduce risk of extinction and loss of genetic diversity and expand the distribution, abundance, and diversity of Lake Ozette sockeye salmon.

Attachment 3. Proposal for identification of spawning aggregations of Lake Ozette Sockeye salmon for enhancement recovery strategies using isotopic composition of otoliths and thermal otolith marking.

Project Abstract

This project provides baseline demographic information for testing 1) whether sockeye salmon can be successfully reintroduced into tributaries of Lake Ozette, where they were extinct, and 2) whether distribution and abundance of beach spawning aggregations can be rebuilt through supplementation. The ability to mark and identify hatchery fish is essential to monitor recovery efforts, but some of the hatchery-produced sockeye salmon will be released before external markings are possible. Consequently, this project tests the efficacy of the combined methods of differential thermal otolith marking and analysis of stable isotopic composition of otoliths from sockeye salmon originating from different release strategies or locations as monitoring tools. Otolith marking and identification will allow co-managers to develop effective strategies to monitor abundance, distribution, interactions among natural and hatchery aggregations, and the effectiveness of different rearing and release strategies. Project results will be summarized in a final technical report to the funding agency, co-managers, and to the National Marine Fisheries Service (NMFS) and will be incorporated into the Lake Ozette Sockeye Hatchery Genetic Management Plan, the Lake Ozette Sockeye Recovery Plan, and the Tribal Resource Management Plan for Lake Ozette sockeye salmon.

Project Goals:

The goal of this project is to develop demographic monitoring tools that can be used to test: 1) whether sockeye salmon can be successfully reintroduced into tributaries of Lake Ozette, where they were extinct, and 2) whether distribution and abundance of beach spawning aggregations can be rebuilt through supplementation. Results of this research will be incorporated into the Lake Ozette Sockeye Hatchery Genetic Management Plan and will provide a key component in the adaptive management strategy for recovering Lake Ozette sockeye salmon.

Objectives:

Objective 1: Conduct and evaluate differential thermal otolith marking as a tool to estimate reproductive success, survival, age composition, and distribution of hatchery fish of different release rearing and strategies and locations.

Objective 2: Use stable isotopic composition of otoliths as a chemical tracer to discriminate indicative isotopic differences among different spawning areas to determine the origin of different lake and tributary aggregations of Lake Ozette sockeye. This technique will be used to monitor the origins of returning adult Lake Ozette sockeye in 2001-2003 that result from earlier releases when no thermal otolith marking was accomplished, to provide quality assurance, quality control, and to provide a back up method to thermal marking beginning in 2004 and beyond, and to monitor natural spawning aggregations of Lake Ozette sockeye that are not thermally marked in a hatchery. Distribution, survival, and reproductive success may also be monitored without handling fish using this non- intrusive technique.

Objective 3: Communicate results.

Objective 4: Implement hatchery reform through adaptive management.

Background and Rationale:

The Makah Tribe is developing a long-term strategy for how to use artificial propagation to rebuild and recover anadromous Lake Ozette sockeye salmon. Details of the hatchery facilities, operational protocols, performance standards, and risk analysis are available in the Lake Ozette Sockeye Hatchery Genetic Management Plan Section 7 Biological Assessment. The strategy, however, has two targets: (1) reintroducing sockeye salmon to the tributaries of Lake Ozette, where they were extirpated and (2) rebuilding beach spawning aggregations. Current hatchery activities include reintroduction and supplementation in the two main tributaries to Lake Ozette, Big River and Umbrella Creek, and reintroduction and supplementation along lakeshore beaches.

Supplementation of beach spawning aggregations is contingent on determining the factors that are limiting the abundance and distribution of sockeye along the lake, whether the limiting life history stages can be addressed by artificial production, and identifying the genetic population structure among aggregations.

Reintroduction of sockeye salmon to the tributaries is a unique opportunity to test whether it is possible to restore not only abundance and productivity but also the spatial structure and diversity of declining spawning aggregations. Rebuilt abundance, spatial structure, productivity, and diversity are indicators of population viability and are a major part of the National Marine Fisheries Service's goal for recovery of salmon (McElhany *et al.* 1999; FR 65(1):170-196). Accomplishing this presents enormous evolutionary and management challenges that have not been well studied. Most research has been focused on the success or risks of artificial production in rebuilding or maintain existing populations rather than on the success of reintroduced or extirpated populations within a threatened metapopulation or evolutionarily significant unit (ESU).

Lake Ozette is especially suited for this kind of experiment. The population structure of the ESU is simple and contained within a relatively small geographical scale. Many of the problems facing the ESU such as degradation of habitat and introduction of exotic plants and animals are common to other threatened metapopulations. Unlike many areas where supplementation is being studied, however, the results in Lake Ozette will not be confounded by mortality at hydroelectric dams or harvest. No harvest has occurred in since 1984, and in the 10 years before that ceremonial and cultural harvest averaged 25 fish per year.

The results from this hatchery experiment in reintroduction could be valuable in other areas. Sockeye salmon and coho salmon have been extirpated from major areas of the Columbia River. Unique life history races of salmon, such spring chinook, have disappeared from many streams within the Puget Sound, leaving only a few remnant populations within the ESU. The future removal of barrier dams, such on the Elwha River, is raising questions of whether it is possible to devise an appropriate artificial production strategy for reintroducing anadromous salmonids to areas where they have been extirpated. In addition, an understanding of how rapidly salmon can adapt and diversify could have major implications for Puget Sound chinook salmon in areas lacking indigenous populations, such as the Puyallup, Nisqually, and Skokomish Rivers.

In 1999, Makah Fisheries Management (MFM) funded a study in collaboration with the WDFW Otolith Laboratory in Olympia, Washington, to examine natural otolith banding patterns resulting from eggs incubated in lake and tributary water to see if a natural "riverprint" could be detected in river spawners (copy of final report is available from MFM or WDFW Otolith Laboratory). Replicated incubators were weighted to the lake bottom housed within nylon bags to collect emerging alevins. The incubators were placed adjacent to a series of thermographs which measured subgravel, above gravel, and within water column water temperatures in the lake.

At the same time, eggs from the same parentage were also incubated until hatching at the Umbrella Creek Hatchery, which is supplied by water from a tributary to Umbrella Creek at RM 4.5, to compare natural banding patterns of newly hatched fry of known incubation locations of lake - and tributary -origin upon emergence. Upon emergence, alevins were sacrificed and their otoliths were compared between these known stream or lake incubation environments.

Otoliths originating from both lake beaches were distinguishable from otoliths of natural origin recruits hatched from sockeye eggs pumped from gravel in Umbrella Creek and from eggs of lake origin that were incubated at the Umbrella Creek Hatchery, but eggs incubated on Allen’s and Olsen’s Beaches were not distinguishable from one another as postulated.

Upon examining river - and lake - origin otoliths in emergent fry, adult returns to Olsen’s Beach (lake) and Umbrella Creek (tributary) were compared (blind analysis) to see if examiners could distinguish signature thermal banding patterns, for lake or tributary origin, in their otoliths. A total of only three adults were examined for otolith banding patterns from Umbrella Creek but a total of 95 adults were sampled from Olsen’s Beach. Blind reading of the otoliths indicated that 3/3 (100%) of the fish from Umbrella Creek were correctly identified as tributary origin fish. Of the beach spawners, 83.2% were identified to be of lake origin, 14.7% were identified to be of tributary origin, and 2.1% were unknown. The percentage of the 95 fish sample from Olsen’s Beach determined to be of lake origin by otolith analysis (83.2%) was close to the expected percentage of beach spawners (95%), being off by 11.8%.

This analysis is important because it demonstrates that fish of tributary or of lake origin can be identified by otolith banding patterns, with a fair amount of precision, on years when no otolith marking occurred or in natural spawning aggregations that are not subject to otolith marking. Recent research has shown that stable isotopic composition of otoliths can be used as a chemical tracer to discriminate stocks and migration patterns (Gao and Beamish 1999), if there are indicative isotopic differences among different water masses or habitat areas. For freshwater settings, Nelson *et al*. (1989) compared the □^{18}O value of otoliths in common smelt (*Retropinna retropinna*) with that of water sources, and concluded that there was a potential to use stable isotopes, in both □^{18}O and □^{13}C, to distinguish smelt by their habitat waters and by examining their migration behavior. Therefore, if there are distinct physical and biological differences among lake spawning beaches, Umbrella Creek, and Big River, it may be possible to establish a chemical tool for discrimination of the different spawning aggregations of Lake Ozette sockeye salmon.

In particular, we are interested to know the isotopic values and variation ranges of sockeye otoliths recovered from fry and adults from each of two lake and two tributary spawning areas, respectively, in an attempt to establish isotopic standards to identify and monitor the relative abundances of wild and hatchery fish in future supplementation and reintroduction efforts. If successful, the chemical tool or tracer may provide a low cost and more effective alternative to DNA analysis to not only identify aggregations of Lake Ozette sockeye but also, this technique may be applicable to identify stocks of salmon or groundfish in other mixed stock fisheries, etc.

Ecological and Genetic Characteristics:

Lake Ozette is a unique lake with an evolutionarily distinct group of sockeye salmon. Located in the isolated northwest corner of Washington, the lake occupies 2,954 ha in the middle of a once lush Olympic rainforest community. The lake is fed by numerous low-to-moderate gradient ephemeral and perennial streams and is drained by the Ozette River approximately 8 km into the Pacific Ocean. Intensive road building and clear-cut logging of Sitka spruce (*Picea sitchensis*) and western hemlock (*Tsuga heterophylla*), which once dominated the Lake Ozette watershed, have reduced most of the forest and riparian areas to early successional stands of red alder (*Alnus rubra*) and mixed conifers, and is thought to have buried and cemented spawning gravels in streams and beaches under increased silt loads and is also presumed to have increased the incidence and intensity of run off contributing to high flows that can destroy salmon redds.

Anadromous sockeye salmon are thought to have once spawned in several tributaries and along lake beaches (Dlugokenski *et al*. 1981; Blum 1988; Jacobs *et al.* 1996; MFM 2000). The historical abundance of these sockeye is poorly documented. In the first study of lake escapement of Ozette sockeye (Kemmerich 1945), the run size entering the lake was estimated at a level of several thousand fish. These counts are assumed to have been conducted upstream from fisheries in or near to the Ozette River. Verbal reports from fish buyers of sockeye harvested in saltwater near to the Ozette River purportedly ranged from 14,556 to 17,638 fish during a three-year period from 1949 to 1951. These catches were attributed to be from the Ozette River as reported by Dlugokenski *et al.* (1981) and later in Jacobs *et al.* (1996); however, there were and are no written fish tickets or other records of these harvests (Jeff Haymes, WDFW, personal communication). While catches declined from several thousand sockeye to less than 100 fish within the following 20 years, these three large catches appear disproportionately large relative to any other years recorded. During this same period, large catches of Lake Quinault sockeye, averaging approximately 120,000 fish, were reported from the Quinault River, located to the south of the Ozette River, as reported by Ward *et al.* (1976) and Gilbertson (1981) In Jacobs *et al*. (1996). Dlugokenski *et al*. (1981), reported that, "Catch data from 1948 through 1972 is extremely unreliable and is presented here primarily to illustrate a general decline in harvest." While it may not be reliable to use these verbal catch reports from fish buyers as a measure of historic abundance, there remains a significant decline in catch beginning in the 1950's and a significant decline in run size since the work of Kemmerich (1945).

Evidence indicates that the release of fry derived from lake spawners into Umbrella Creek appears to have resulted in a self-sustaining run in that tributary to Lake Ozette. In 1996, 101 sockeye salmon spawned in Umbrella Creek as descendants of this release. This is known because nearly all Lake Ozette sockeye are four-year-olds and no hatchery fish were released in 1992. Therefore fish spawning in Umbrella Creek in 1996 were of natural origin. In 1999-2000, the estimated number of sockeye spawning in the Umbrella Creek was approximately 400 of which approximate 149 were of natural origin. The number of natural origin fish per mile of stream increased from 19 to 52 (MFM 2000).

The apparent success of sockeye salmon in Umbrella Creek conflicts with suggestions in the scientific literature that lake spawning sockeye salmon may face large challenges in colonizing and adapting to the stream environment. Stream spawning stocks have been postulated to have unique physiological adaptations for surviving in streams and migrating to the sea, such as larger eggs, the ability to tolerate higher levels of fine sediment, faster growth, more rapid seawater adaptability, and increased propensity for straying relative to lake spawning stocks (Lorenz and Eiler 1989, Rice *et al*. 1994, Wood 1995).

With the exception of the Fraser River, natural stream spawning sockeye salmon are also rare south of the Stikine River. However, sockeye salmon introduced from the Baker River into the Cedar River south of Seattle have grown to be the largest natural spawning sockeye salmon population in the contiguous United States. Lack of stream spawners in some of the other southern areas may have been due to: 1) insufficient colonists from northern areas with the genetic capacity for adapting the necessary life history; 2) lack of suitable habitat; or 3) small, unique stream spawning stocks (such as the Ozette stocks) that were overlooked or extirpated before extensive surveys began (Halupka *et al.* 1993). Whether the appearance of sockeye salmon in Umbrella Creek was a fortuitous example of founder effect and rapid selection following Wright's shifting balance theory of evolution (Wright 1931) or the lake spawners already had the necessary adaptations, is unclear.

Artificial Production Strategy

The apparent success of these fish in Umbrella Creek suggests that sockeye salmon derived from native lake spawners may be capable of reestablishing in Lake Ozette tributaries, despite the enormous evolutionary and ecological challenges. Reintroduction may be able to exploit the success of Umbrella Creek fish. The basic strategy for reintroduction is to use sockeye salmon returning to Umbrella Creek from throughout the run as the source of brood stock to seed the two main tributaries to Lake Ozette, Big River and Umbrella Creek. Approximately 40 pairs of males and females will be used for brood stock initially for supplementation in Umbrella Creek and approximately 60 pairs may be used for reintroduction to Big River. Matings will be based on a 4 x 4 factorial design to maximize genetic effective population size, including natural origin fishes.

Fish may be introduced as (1) eyed eggs, (2) unfed fry, or (3) fed fry and fingerlings. To test the success of these different treatments, all fish will be differentially thermally otolith marked as eyed eggs, beginning in 2000. Consequently, evaluating the success of thermal otolith marking is essential to this strategy, which will begin in 2004. Since hatchery sockeye released prior to 2000 and all wild sockeye were not otolith marked, an alternate strategy to identify these fish is needed. An alternative method which measures differences in stable isotopes of carbon and oxygen in otoliths is proposed for identification of different spawning aggregations of unmarked sockeye, quality assurance and control of the thermal marking method, and for long term non-intrusive monitoring of supplementation efforts in the Basin.

All fish released at a weight greater than 0.5 gm will also have the adipose fin clipped. Sockeye will be reintroduced only into streams that lack abundant kokanee and that have suitable habitat. Monitoring plans call for evaluating potential hybridization with kokanee salmon and changes in the life history of the fish. The current program is slated for 12 years or three generations (2000 to 2012).

Risk Assessment and Risk Management

Despite the apparent value of artificial propagation as a conservation tool (see reviews in Olney *et al*. 1994), it does pose genetic and ecological risks in salmon (Hindar *et al*. 1991, Waples 1991, Busack and Currens 1995, Campton 1995, Waples 1995, Allendorf and Waples 1996). These risks for Lake Ozette are described below. The major purpose of this research is to provide the baseline information that will allow the Makah Tribe to address these risks and design a program to test whether reintroduction can be successful.

1. **Loss of Among-Population Diversity** The two major sources of loss of among-population diversity are (a) potential hybridization of kokanee and sockeye salmon and (b) straying of returning Umbrella Creek fish to lake spawning aggregations. The likelihood of this happening is low, but vulnerability (see Currens and Busack 1995 for discussion of terms) is considered high because of the potential consequences. Culture and release of Umbrella Creek fish may disrupt the natural reproductive isolating mechanisms that have kept lake spawners and kokanee or different spawning aggregations of lake spawners distinct. This could result in poor performance resulting from outbreeding depression for crucial life history traits.

   For example, although kokanee salmon in other areas have displayed migratory characteristics where saltwater was available (Chapman 1941, Foerster 1947, Rounsefell 1958, Fulton and Pearson 1981), kokanee populations in other areas, including Lake Ozette and Lake Cowichan, do not (Dlugokenski *et al.* 1981, Rutherford et al. 1988). Limiting sockeye reintroductions to Umbrella Creek and Big River, which have no spawning populations or very small numbers of kokanee, reduces this risk.

Also, no straying of tributary returning, hatchery-origin, adults to the lake beaches was observed in the 1999 return (0/121 of lake spawners sampled were adipose clipped), which is the only return year where marked hatchery-origin returning adults were monitored in the lake spawning aggregations after a tributary release. The baseline genetic information needed to determine whether lake spawning aggregations are really different and to design a monitoring plan for these risks was requested in a separate proposal which will be complemented with this proposal and will enable identification of hatchery returning adults.

2. **Loss of Within-Population Diversity** Use of returning Umbrella Creek hatchery fish for reintroduction limits the potential brood stock mining of wild lake spawning aggregations and any effects that may have on reducing the effective population size. The estimated composite hatchery-wild genetic effective population size is 1,750 (range 436-3,064, Currens unpubished data), suggesting that loss of within-population diversity is unlikely to be a major concern in the ESU in short or moderate duration programs.

If naturally produced sockeye salmon returning to Umbrella Creek represent an evolving subpopulation, it is possible that supportitive breeding could reduce the effective population size of this spawning aggregation. It seems likely that Umbrella Creek fish may already have undergone a significant founder effect. A marking systems that will allow the Makah Tribe to distinguish hatchery from naturally produced fish is a key component in managing this risk.

Domestication Overall vulnerability to domestication is low to moderate depending on the strategy. The best available strategy for limiting domestication is to limit the time spent in an artificial environment and to minimize the use of hatchery origin fish in the brood stock. Overall, the duration and intensity of culture of Ozette sockeye has been very minimal compared to artificial production of other species. The artificial production strategy proposes three treatments that vary in the intensity and duration of culture ranging from release of eyed eggs to release of fed fry.

Planting of eyed eggs is required for reintroduction strategies to allow for imprinting to their new release environment. Monitoring has suggested that flow conditions in spring and life history of unfed fry may be more conducive to outmigration while fed fry or fingerlings may survive at a higher rate once in the lake. Survival of fed fry and fingerlings will be compared to that of unfed fry, which can only be otolith marked. Also, eyed eggs are slated for reintroduction to Big River to avoid imprinting after hatching on the hatchery water supply in the Umbrella Creek system.

The test of otolith marking proposed in the research is essential for determining the relative success of different treatments. This is necessary to make wise choices about the trade-offs. In addition, the otolith survey of existing *O. nerka* spawning aggregations will provide baseline life history information that may be useful in assessing the potential changes in the behavior or demographics of hatchery fish, which might indicate domestication effects.

3. **Predation and Competition** Vulnerability to predation and competition from hatchery introductions is low. In all tributaries, except Umbrella Creek, there are no natural anadromous sockeye to compete with or prey on. In Umbrella Creek, interactions on the spawning grounds and population dynamics of the natural and wild fish will be monitored to determine whether the abundance of hatchery fish is having a significant density dependent impact on natural origin recruits. Competition and predation between kokanee and anadromous sockeye salmon in the streams is minimized by limiting reintroduction to streams where kokanee are rare or absent. Juvenile sockeye salmon and kokanee migrate to the pelagic zone of the lake to rear soon after emergence (Jacobs *et al.* 1996), reducing other potential ecological interactions in the streams.

During residence in the lake, kokanee, naturally produced sockeye, and hatchery produced sockeye feed primarily on *Daphnia pulicaria*, but competition is assumed to be minimal. Bioenergetic simulations (Beauchamp *et al*. 1995), size of smolts (Dlugokenski *et al*. 1981), and production of zooplankton in Lake Ozette (Bortleson and Dion 1979) all indicate that food supplies in the lake are not limiting.

4. Catastrophic Failure in the Hatchery Incubation facilities at Umbrella Creek have been based on a low technology approach, because of the isolation and small scale of the program. This raises the potential for catastrophic losses in the hatchery. To help reduce this risk, the Umbrella Creek facility will be used for holding brood stock for brief periods before spawning and the Educket Hatchery, where facility problems can be more readily monitored and corrected, will be used for egg incubations. Long-term plans call for eggs to be incubated at Makah National Fish Hatchery, after the construction of a new isoincubation quarantine facility.

4. Study design and methods

Objective 1: Otoliths of artificially propagated sockeye salmon incubating at the Educket Hatchery (2000/2001) or Makah National Fish Hatchery (2001/2002) with be uniquely otolith marked by manipulating water temperatures. Temperatures of eyed eggs will be manipulated by moving trays of eggs between Heath/FAL stacks supplied with heated or ambient temperature water. Water will be heated by passing it through two 220 volt, 6000-watt stainless steel water heaters attached to a single Heath/FAL stack. A rapid 10°F (5.6°C) drop in water temperature during incubation was shown to create distinct banding patterns in otolith microstructures during 1999/2000 otolith marking at the Educket Creek Hatchery (WDFW and MFM unpublished data). By implementing a different sequence of temperature changes for each treatment group, we will induce a unique, permanent pattern in the microstructure of the otoliths before the fish are released. A sample of 20 individuals will be archived from each treatment group to document each reference pattern.

In addition, otoliths from 180 spawners, sampled from Umbrella Creek during brood stock collection, will be examined to provide baseline data on growth, age, and migration. Each sample will include a unique sample number, sample date, and sample location. To identify patterns, sagittal otoliths will be dissected from the fish. Otoliths will be mounted, sectioned, lapped, and polished until the microstructure of each is clearly visible. The prepared otolith will be examined independently with a compound microscope at 200x and/or 400x magnification by two different otolith readers to determine the pattern. Adult sockeye hatchery returns, beginning in 2004, will be identified to treatment group by comparing their otolith banding pattern to the archived reference pattern. Money for this analysis will be sought later. Once the patterns have been identified and compiled, the data will be analyzed to evaluate the effect of different release treatments on growth, survival, stray rates, and age composition.

Objective 2: We propose to adapt a new stock discrimination technique that utilizes stable isotope ratios ($^{18}O/^{16}O$ and $^{13}C/^{12}C$) of salmon otoliths from different lake and tributary spawning areas. It is presumed that there are considerable differences between spawning areas in physical and biological conditions, such as water temperature, salinity, chemical components, nutrient loading, and productive status of the different water systems. Therefore, as theoretically and experimentally suggested (Urey 1947; Epstein *et al.* 1953; Grossman and Ku 1986; Kalish 1991; Patterson *et al.* 1993), when otoliths form in different waters they will lock the isotopic information that faithfully reflects the ambient environment in $^{18}O/^{16}O$ (water conditions) and $^{13}C/^{12}C$ (trophic conditions) ratios. It is also assumed that the stocks may have some unique internal characteristics, including some genetic isolation. Therefore, the life history (*i.e.*

incubation habitats, timing of fry migration to the lacustrine environment, and return timing of different spawning aggregations) may be significantly different.

Sagittal otoliths of sockeye salmon will be cleaned in a supersonic water bath for approximately 15 minutes, rinsed with ethanol, and air dried. The methods for embedding, sectioning, and polishing otoliths have been reported elsewhere (Gao and Beamish 1999). Microsampling will be undertaken at two scales: medium resolution of individual annuli (aimed at summer growth zones) to evaluate the long-term, inter-annual isotopic changes; and high resolution at 20-40 μm intervals, to evaluate the seasonal isotopic variations during early life history of fry. At medium resolution, a core will be removed from the opaque otolith zones or annual rings using the Dremel sampling method (cf. Gao, 1999). At high resolution, otolith thin sections will be imaged with transmitted light to elucidate the growth structure for aging of the individual.

The image will be stored digitally for subsequent microsampling by a computer driven microsampler (cf. Patterson *et al*., 1993). In both cases, 30-50 μg of aragonite powder material from otolith surfaces will be collected for stable isotope analysis. The powder samples will be reacted with 100% phosphoric acid to liberate CO_2 gas that is fed into a mass spectrometer (Optima in McMaster University, Canada or a Finnigan MAT-252 in Syracuse University, New York, depending on the laboratory arrangements), using an Autocarb carbonate analyser. All the measurements are reported in the standard δ notation (‰), such as $\delta^{18}O = \{[(^{18}O/^{16}O)_X / (^{18}O/^{16}O)_S] - 1\} \times 1000$, where X is sample and S is standard (VPDB via NBS-19). The precision of analyses is better than ±0.06 ‰ for both carbon and oxygen isotopes.

Significance of the research:
The isotopic technique has been rarely used in stock identifications and has never been used in such closely related spawning aggregations. Thus, the proposed project may provide the first definitive information about the environmental conditions during early life history of spawning aggregations of Lake Ozette sockeye.

Since climate-related ecosystem changes are believed to play an important role in the spawning and abundance of Pacific salmon (Beamish and Bouillon 1993), this isotope detection method will be very useful for discrimination of other stocks in mixed stock fisheries or wherever there are significant, predictable differences among environmental conditions of rearing environments of different fish stocks or spawning aggregations. In addition, the isotopic composition of otoliths may have other significant applications in hatchery management by providing meaningful information on otolith geochemistry, such as isotopic equilibrium conditions as fish are reared, the temperature dependent fractionation between otoliths and ambient waters, and the optimal growth parameters for various species at various stages of development.

The principle users of this stable isotope data and the research will be fishery and hatchery managers (multi-species), fishermen, and advisory members of the fishery community. Their practice and input will be in turn to substantiate or correct our research conclusions, and encourage us to sharpen the isotopic tool in the future. Findings will have direct application in monitoring and risk assessment programs and methods required for adaptive management as tribal and non-tribal HGMP's are formulated and executed throughout the Northwest.

Partnership groups:

Washington Department of Fish and Wildlife Otolith Laboratory, Olympia, Washington.

Anticipated outcomes/benefits:

Objectives 1 and 2: The results from this study will help to annually determine population abundance, productivity, structure, and diversity and will allow us to determine whether otolith marking can be used to mark and identify different treatment groups of Lake Ozette sockeye salmon. Otolith identification will enable monitoring of different release strategies to determine the optimal methods to increase survival of the ESU. Otolith identification will enable monitoring of straying needed for risk assessment and monitoring and will enable determination of the status of both wild and hatchery spawning aggregations of Lake Ozette sockeye. The ability to identify experimental fish by origin is crucial to measuring changes in reproductive success, survival, age composition, and distribution of hatchery fish and natural sockeye salmon and for appropriately modifying the hatchery program in the future. These results and their management implications will immediately be evaluated and incorporated into the Lake Ozette Sockeye Hatchery and Genetic Management Plan and Tribal Resource Management Plan required for Section 4(d) exemptions under ESA, and will be part of the overall Lake Ozette Sockeye Recovery Plan. Results will be summarized in annual and final reports.

Objective 3: Communication of the findings will provide scientists, fishery and hatchery managers, and the public with access to data and an understanding of how science is being incorporated directly into hatchery management and reform.

Objective 4: The anticipated outcome of this objective is more effective hatchery operations that reduce risk of extinction and loss of genetic diversity and expand the distribution, abundance, and diversity of Lake Ozette sockeye salmon.

Figure 1. Project Time Line

Tasks	**Year X**				**Year X+1**				**Year X+2**
	Winter	Spring	Summer	Fall	Winter	Spring	Summer	Fall	Winter
Objectives 1&2: Test otolith marking									
Collect and prepare samples (isotope analysis)									
Mass spectrometry, data compilation and input									
Objective 3: Communicate results									
Complete annual report									
Complete final report									
Post on website									
Objective 4: Implement changes									
Evaluate existing strategies									
Incorporate modified strategies									

LITERATURE CITED

Allendorf, F. W., and R. S. Waples. 1996. Conservation and genetics of salmonid fishes. Pages 238-280 in J. C. Avise and J. L. Hamrick, editors. Conservation genetics: case histories from nature. Chapman and Hall, New York.

Beacham, T. D., Margolis, L., and Nelson, R. J. 1998. A comparison of methods of stock identification for sockeye salmon (*Oncorhynhcus nerka*) in Barkley Sound, British Columbia. North Pac. Anad. Fish. Comm. Bull. 1:227-239.

Beacham, T. D., and C. C. Wood. 1999. Application of microsatellite DNA variation to estimation of stock composition and escapement of Nass River sockeye salmon (*Oncorhynhcus nerka*). Can. J. Fish. Aquat. Sci. 56:297-310.

Beamish, R.J., and Bouillon, D.R. 1993. Pacific salmon production trends in relation to climate. Can. J. Fish. Aquat. Sci. 50**:** 1002-1016.

Beauchamp, D.A., and M.G. LaRiviere. 1993. An evaluation of competition and predation as limits to juvenile sockeye salmon production in Lake Ozette, Washington. Final Report to Makah Tribe. Makah Fisheries Management, Neah Bay, WA. 67 pp.

Beauchamp, D.A., M.G. LaRiviere, and G.L. Thomas. 1995. Evaluation of competition and predation as limits to juvenile kokanee and sockeye salmon production in Lake Ozette, Washington. N. Am. J. Fish Manage. 15:193-207.

Blum, J.P. 1988. Assessment of factors affecting sockeye salmon (Oncorhynchus nerka) production in Ozette Lake, WA. M.S. Thesis. University of Washington, Seattle, WA. 107 pp.

Bortleson, G. C., and N. P. Dion. 1979. Preferred and observed conditions for salmon in Ozette Lake and it's tributaries, Clallam County, Washington. U.S. Geological Survey Water Resources Investigations. 78-64.

Brannon, E.L. Aquaculture Department, College of Forestry, Wildlife and Range Sciences, University of Idaho, Moscow, ID.

Burgner, R.L. 1987. Factors influencing age and growth of juvenile sockeye salmon *(Oncorhynchus nerka*) in lakes. Pages 129-142 In H.D. Smith, L. Margolis, and C.C. Wood, eds. Sockeye salmon (*Oncorhynchus nerka*) population biology and future management. Can. Spec. Publ. Fish. Aquat. Sci. 96.

Busack, C. A., and K. P. Currens. 1995. Genetic risks and hazards in hatchery operations: fundamental concepts and issues. Pages 71-80 in H. L. Schramm, Jr. and R. G. Piper, editors. Uses and effects of cultured fishes in aquatic ecosystems. American Fisheries Society, Bethesda, Maryland.

Campton, D. E. 1995. Genetic effects of hatchery fish on wild populations of Pacific salmon and steelhead: what do we really know? Pages 337-353 in H. L. Schramm, Jr. and R. G. Piper, editors. Uses and effects of cultured fishes in aquatic ecosystems. American Fisheries Society, Bethesda, Maryland.

LITERATURE CITED

Chapman, W. M. 1941. Observations on the migration of salmonid fishes in the Upper Columbia River. Copeia 1941(4): 240-242.

Crewson, M. Makah Fisheries Management Department, P.O. Box 115, Neah Bay, WA. 98357.

Currens, K. P., and C. A. Busack. 1995. A framework for assessing genetic vulnerability. Fisheries 20(12): 24-31.

Currens, K. Northwest Indian Fisheries Commission, Lacey, WA.

Dlugokenski, C.E., W.H. Bradshaw, and S.R. Hager. 1981. An investigation of the limiting factors to Lake Ozette sockeye salmon production and a plan for their restoration. U.S. Fish and Wildl. Serv., Fish. Assist. Off., Olympia, WA. 52 pp + unnumb. appendices.

Easton, D. Olympic National Park, Lake Ozette Ranger Station, Lake Ozette, WA.

Epstein, S., Buchsbaum, R., Lowenstam, H.A., and Urey, H.C. 1953. Revised carbonate-water isotopic temperature scale. Geol. Soc. Am. Bull. 64: 1315-1326.

Federal Register Notice (FR 64 14528). 1999. Final Rule - Endangered and Threatened Species: Threatened Status for Ozette Lake Sockeye Salmon in Washington. Effective date - May 24, 1999. 50 CFR Part 223. Federal Register, March 25, 1999.

Federal Register Notice (FR 65 170). 2000. Proposed Rule - Endangered and Threatened Species; Proposed Rule Governing Take of Seven Threatened Evolutionarily Significant Units (ESUs). 50 CFR Part 223. Federal Register, January 3, 2000.

Federal Register Notice (FR 65 7764). 2000. Final Rule - Designated Critical Habitat: Critical Habitat for 19 Evolutionarily Significant Units of Salmon and Steelhead in Washington, Oregon, Idaho, and California. 50 CFR Part 226. Federal Register, February 16, 2000.

Foerster, R. E. 1947. Experiment to develop sea-run from land-locked sockeye salmon (Oncorhynchus nerka kennerlyi). J. Fish. Res. Board Can. 7(2): 88-93.

Foerster, R.E. 1968. The sockeye salmon, *Oncorhynchus nerka*. Bull. Fish. Res. Board Can. No. 162.

Fulton, L. A., and R. E. Pearson. 1981. Transplantation and homing experiments on salmon, Oncorhynchus spp., and steelhead trout, Salmo gairdneri, in the Columbia River system: fish of the 1939-1944 broods. U. S. Dept. Commer., NOAA Tech. Memo. NMFS F/NWC 12.

Gau, Y.W., and Beamish, R.J. 1999. Isotopic composition of otoliths as a chemical tracer in population identification of sockeye salmon (*Oncorhynchus nerka*). Can. J. Fish. Aquat. Sci. 56: 2062-2068.

Gearin, P.J., L.L. Lehman, K.M. Hughes, L. Cooke, R.L. Delong, and M.E. Gosho. 1998. Investigations of pinniped interactions with Lake Ozette sockeye salmon, Oncorhynchus nerka, 1998. U.S. Dept. Commer., NOAA, National Marine Mammal Laboratory, Alaska Fisheries Science Center, Seattle, WA., and Makah Fisheries Management, Neah Bay, WA. Unpublished report. 33 pp.

LITERATURE CITED

Gilbertson, L. 1981. Quinault River sockeye salmon. In 1981 preseason management report for spring and summer fisheries on the Quinault and Queets Rivers. Quinault Fisheries Division of the Quinault Department of Natural Resources. Taholah, WA. 60pp.

Grossman, E.L., and Ku, T.-L. 1986. Oxygen and carbon isotope fractionation in biogenic aragonite: temperature effects. Chem. Geol. 59**:** 59-74.

Gustafson, R.G., T.C. Wainwright, G.A. Winans, F.W. Waknitz, L.T. Parker, and R.S. Waples. 1997. Status review of sockeye salmon from Washington and Oregon. U.S. Dept. Commer., NOAA Tech. Memo. NMFS-NWFSC-33. 282 pp.

Haggerty, M. Makah Fisheries Management Department, P.O. Box 115, Neah Bay, WA. 98357.

Halupka, K. C., J. K. Troyer, M. F. Wilson, M. B. Bryant, and F. H. Everest. 1993. Indentification of unique and sensitive sockeye salmon stocks of Southeast Alaska. For. Sc. Lab., Pac. N. W. Res. Stat., U.S. Dept. Agriculture.

Haymes, J. Washington Department of Fish and Wildlife, Olympia, WA.

Hard, J.J., R.P. Jones Jr., M.R. Delarm, and R.S. Waples. 1992. Pacific salmon and artificial propagation under the Endangered Species Act. U.S. Dept. Commer., NOAA Tech. Memo. NMFS-NWFSC-2.

Hershberger, W.K., J. Seeb, and P. Aebersold. 1982. Genetic analysis of the sockeye salmon (Oncorhynchus nerka) returning to Lake Ozette. Unpublished report to Steve Joner, Makah Fisheries Management, from W.K. Hershberger. School of Fisheries, University of Washington, Seattle, WA. 9pp.

Hindar, K., N. Ryman, and F. Utter. 1991. Genetic effects of cultured fish on natural fish populations. Canadian Journal of Fisheries and Aquatic Sciences 48:945-957.

Hughes, K. Makah Fisheries Management Department, P.O. Box 115, Neah Bay, WA. 98357.

Jacobs, R., G. Larson, J. Meyer, N. Currence, J. Hinton, M. Adkison, R. Burgner, H. Geiger, and L. Lestelle. 1996. The sockeye salmon *Oncorhynchus nerk*a population in Lake Ozette, Washington, USA. U.S. Dept. Interior, NPS Tech. Report NPS /CCSOSU /NRTR-96 /04.

Johnson, D.H. and T.A. O'Neil. 2000. Pacific salmon and wildlife: Ecological contexts, relationships, and implications for management. Special edition technical report. Wildlife-habitat relationships in Oregon and Washington.

Kalish, J.M. 1991. Oxygen and carbon stable isotopes in the otoliths of wild and laboratory-reared Australian salmon (*Arripis trutta*). Mar. Biol. 110**:** 37-47.

Kemmerich, J. 1945. A review of the artificial propagation and transplantation of the sockeye salmon of the Puget Sound area in the State of Washington conducted by the federal government from 1868 to 1945. U.S. Fish and Wildl. Serv., unpubl. M. Sc. 116 pp.

LITERATURE CITED

LaRiviere, R.G. 1991. Lake Ozette sockeye salmon studies: Adult weir operations, 1988-1990. Makah Tribe Project Rept. 91-1. Makah Fisheries Management Department, P.O. Box 115, Neah Bay, WA. 98357.

Lorenz, J. M., and J. HJ. Eiler. 1989. Spawning habitat and redd characteristics of sockeye salmon in the glacial Taku River, British Columbia and Alaska. Trans. Am. Fish. Soc. 118: 495-502.

McElhany, P., M. Ruckelshaus, M. J. Ford, T. Wainwright, and E. Bjorkstedt. 1999. Viable salmonid populations and the recovery of evolutionarily significant units. National Marine Fisheries Service, Northwest Fisheries Science Center, http://research.nwfsc.noaa.gov/pubs/nwfscpubs.html.

McHenry, M.L., D.C. Morrill, and N. Currence. 1994. Spawning gravel quality, watershed characteristics and early life history survival of coho salmon and steelhead in five North Olympic Peninsula watersheds. Unpublished study funded by the Department of Ecology, Centennial Clean Water Fund, and Section 205J Clean Water Act. Elwha Tribe, Port Angeles, WA and Makah Tribe, Neah Bay, WA. 60 pp. and unnumbered Appendices.

Nelson, C.S., Northcote, T.G., and C.H. Hendy. 1989. Potential use of oxygen and carbon isotopic composition of otoliths to identify migratory and non-migratory stocks of the New zealand common smelt: A pilot study. New Zealand J. Mar. & Freshwater Res. 23: 337-334.

Olney, P.J.S., G.M. Mace and A.T.C Feistner (eds.) 1994. Creative Conservation: Interactive management of wild and captive populations. Chapman and Hall, New York. Rice, S. D., R. E. Thomas, and A. Moles. 1994. Physiological and growth differences in three stocks of underyearling sockeye salmon (Oncorhynchus nerka) on early entry to seawater. Can. J. Fish. Aquat. Sci. 51: 974-980.

Patterson, W.P., Smith, G.R., and Lohmann, K.C. 1993. Continental paleothermometry and seasonality using the isotopic composition of aragonitic otoliths of freshwater fishes. *In* Climate change in continental isotopic records. *Edited by* P. Swart, K.C. Lohmann, J. McKenzie and S. Savin. Geophysical Monograph 78**:** 191-202.

Rounsefell, G. A. 1958. Anadromy in North American Salmonidae. U. S. Fish Wildl. Serv., Fish. Bull. 58: 171-185.Rutherford, D. T., C. C. Wood, and J. R. Candy. 1988. Stock assessments and biological investigations of kokanee (Oncorhynchus nerka) in Cowichan Lake, British Columbia. Can. Manuscr. Rep. Fish. Aquat. Sci. 1995.

Rutherford, D. T., C. C. Wood, and J. R. Candy. 1988. Stock assessments and biological investigations of kokanee (Oncorhynchus nerka) in Cowichan Lake, British Columbia. Can. Manuscr. Rep. Fish. Aquat. Sci. 1995.

Urey, H.C. 1947. The thermodynamic properties of isotopic substances. J. Chem. Soc., 562-581.

Steward, C.R. and T.C. Bjornn. 1990. Supplementation of salmon and steelhead stocks with hatchery fish: a synthesis of published literature. Idaho Cooperative Fish and Wildlife Research Unit, Tech. Rpt. 90-1. University of Idaho, Moscow, ID. 126 pp.

LITERATURE CITED

Tynan, T. NOAA/NMFS Sustainable Fisheries Division, Lacey, WA.

Waples, R. S. 1991. Genetic interactions between hatchery and wild salmonids: lessons from the Pacific Northwest. Canadian Journal of Fisheries and Aquatic Sciences 48: 124-133.Waples, R. S. 1995. Genetic effects of stock transfers of fish. Pages 51-69 in D. Philipp, editor. Protection of aquatic biodiversity: proceedings of the World Fisheries Congress, theme 3. Oxford and IBH, New Delhi.

Waples, R. S. 1995. Genetic effects of stock transfers of fish. Pages 51-69 in D. Philipp, editor. Protection of aquatic biodiversity: proceedings of the World Fisheries Congress, theme 3. Oxford and IBH, New Delhi.

Ward, D., R.S. Robinson, and G. Nye. 1976. Fisheries statistical report. Washington Dept. Fish., Olympia, WA. 115pp.

White, L.E. 1986. Successful rehabilitation of a sockeye salmon stock using an egg planting device. In: Proceedings of the 37th Annual Northwest Fish Culture Conference. 21pp.

Winans, G. A., P. Aebersold, and R. S. Waples. 1996. Allozyme variability of Oncorhynhcus nerka in the Pacific Northwest, with special consideration to populations of Redfish Lake, Idaho. Trans. Am. Fish. Soc. 205: 645-663.

Wood, C. C. 1995. Life history variation and population structure in sockeye salmon. In J. L. Nielsen (editor). Evolution and the aquatic ecosystem: defining conservation units in population conservation. Am. Fish. Soc. Symp. 17: 195-216.

Wood, C.C., Riddell, B.E., and Rutherford, D.T. 1987. Alternative juvenile life histories of sockeye salmon (*Oncorhynchus nerka*) and their contribution to production in the Stikine River, northern British Columbia. *In* Sockeye salmon (*Oncorhynchus nerka*) population biology and future management. *Edited by* H.D. Smith, L. Margolis and C.C. Wood. Can. Spec. Publ. Fish. Aquat. Sci. 96**:** 12-24.

Wright, S. 1931. Evolution in Mendelian populations. Genetics 16:97-159.

Appendix A. Potential limiting factors for Lake Ozette sockeye ranked by life stage and by spawning aggregation.

KEY:					
IMPACT	none	low	moderate	high	unknown
RANK	0	1	2	3	?

NOTE: Various life cycle limiting factors are ranked based on best available knowledge (current research, educated opinion, literature review).

SPAWNING AGGREGATION

	BEACHES		TRIBUTARIES		
	OLSEN'S	ALLEN'S	UMBRELLA	BIG RIVER	
LIMITING FACTORS	ADULT SOCKEYE ENTERING THE SYSTEM				[1]Lack of adequate pools, abundance of riffles due to historic woody debris removal. [2]Tidal prism has changed since the 1950s. [3]Harvest of sockeye in this system is no longer occurring.
Predation	2-3	2-3	2-3?	2-3?	
Habitat[1]	2	2	2	2	
Water quality	0	0	0	0	
Tidal prism[2]	1	1	1	1	
Directed harvest[3]	0	0	0	0	
	ADULT SOCKEYE HOLDING IN LAKE				[4]Relationship between disease and predation; injured fish entering the system may be more susceptible to disease.
Predation	0-1	0-1	N/A	N/A	
Disease[4]	1	1	N/A	N/A	
Water quality	0	0	N/A	N/A	
Feeding	0	0	N/A	N/A	
Habitat	0	0	N/A	N/A	
	ADULT SOCKEYE SPAWNING ON BEACHES				[5]There may be enough gravel but not necessarily in the right location (i.e. too deep). [6] Adult sockeye are territorially focused while spawning in shallow water making them more susceptible to mammal predation. [7]High turbidity may affect mate selection efficiency/ability
Gravel quantity/quality	1	1	N/A	N/A	
Habitat[5]	1?	1	N/A	N/A	
Predation[6]	2-3	2-3	N/A	N/A	
Water quality[7]	1-2	1-2	N/A	N/A	
	ADULT SOCKEYE ENTERING TRIBUTARIES				[8]Big River has channel issues and instability that could have negative impact to sockeye
Predation	N/A	N/A	1	1	
Water quality	N/A	N/A	2	2	
Flow rate	N/A	N/A	1	1	
Habitat[8]	N/A	N/A	1	2	

SPAWNING AGGREGATION

	BEACHES		TRIBUTARIES		
	OLSEN'S	ALLEN'S	UMBRELLA	BIG RIVER	
LIMITING FACTORS	**ADULT SOCKEYE SPAWNING IN TRIBUTARIES**				
Gravel quantity/quality[9]	N/A	N/A	1-2	1-2	[9]Examine relationship between wood and gravel quantity and quality. [10]Habitat variables are important; presence or absence of wood may be important. *Note - consistent / uniform habitat unlikely*
Habitat[10]	N/A	N/A	1	1-2	
Predation	N/A	N/A	1	1	
Water quality	N/A	N/A	2	2	
Flow rate	N/A	N/A	2	2	
Competition w/kokanee, etc.	N/A	N/A	0	0	
	EGG INCUBATION IN LAKE				[11]Degree of upwelling, spring activity and impact of inter-gravel flows; upwelling, wave action impacts. [12]Examine relationship between fine sediment and water quality. [13]Examine relationship between water surface elevation and beach spawning habitat. [14]Spawning density, sockeye appear to be competing for minimal spawning areas. [15]How might research / hatchery work affect this stage?
Predation	2-3	2-3	N/A	N/A	
Habitat[11]	2-3	2-3	N/A	N/A	
fine sediment in gravel[12]	3	3	N/A	N/A	
fertilization success	0	0	N/A	N/A	
lake level changes[13]	3	3	N/A	N/A	
water quality	0	0	N/A	N/A	
redd superimposition[14]	1	1	N/A	N/A	
brood stock collection[15]	1	1	N/A	N/A	
	EGG INCUBATION IN TRIBUTARIES				[16]Sculpin and otter egg predation. [17]Presence of upwelling / springs. [18]Average 9.7% < .85 mm. diameter gravel dry method. [19]Potentially difficult adult access to spawning areas [20]Temperature, dissolved oxygen, turbidity, silt charged sediments. [21]Amount of water, increased peak flows and energy; changes in pulse flow. [22]people trampling redds, training should correct this. [23]Human impacts, diking, bridges, culverts, exotic plants.
Predation[16]	N/A	N/A	2	2?	
habitat stability[17]	N/A	N/A	2-3	3	
fine sediment[18]	N/A	N/A	2-3	2-3	
fertilization success[19]	N/A	N/A	0	0	
water quality[20]	N/A	N/A	?	?	
water quantity	N/A	N/A	1	1	
channel stability (scour)[21]	N/A	N/A	2-3	2-3	
redd superimposition	N/A	N/A	1	0-1	
spawning surveys[22]	N/A	N/A	1-2	0-1	
channel morphology alterations[23]	N/A	N/A	1	2-3	

SPAWNING AGGREGATION

	BEACHES		TRIBUTARIES		
	OLSEN'S	ALLEN'S	UMBRELLA	BIG RIVER	
LIMITING FACTORS	**FRY EMERGENCE AND MIGRATION IN LAKE**				[24]There is no data on this, but other research (fyke data, Dickey coho) indicate that it could be high. [25]Lake levels fluctuate 8 -12 feet and may be impacting redds. [26]Cementing aggregate [27]change in large woody debris on beaches and tributaries. [28]If lake hydrology is altered, it can affect migration. *Note: need to compare data between Olsen's and Allen's*
Predation[24]	?	?	2	2	
lake level[25]	1-2	1-2	N/A	N/A	
fine sediment[26]	1-2	1-2	1	1	
change in vegetation[27]	?	?	?	?	
Migration[28]	?	?	?	?	
	FRY EMERGENCE & OUTMIGRATION IN TRIBS				[29]Sculpin predation. [30]Low flows rare in March but may increase predation. [31]Turbidity may benefit survival (minimize visual predator efficiency). [32]Difficult to observe fry (hiding, traveling, feeding). [33]Low velocities and diking near mouth and Trout, Dunham Creeks may have negative impact in Big River.
Predation[29]	N/A	N/A	2	2?	
flow: high/low[30]	N/A	N/A	0-1	0-1	
water quality[31]	N/A	N/A	0	0	
Habitat[32]	N/A	N/A	?	?	
velocity (water)[33]	N/A	N/A	0	2	
	PELAGIC ENVIRONMENT				[34]Determine predator biomass, percentage of sockeye preyed upon, and if predators are native or introduced. [35]Food preference? No shortage of zooplankton, large smolt size indicates adequate feed.
Predation[34]	?	?	?	?	
food availability[35]	1	1	1	1	
	JUVENILE OUT-MIGRATION				[36]Confirm predators, determine biomass, and impacts to population? [37]Water quality: Are there unique water chemistry and hydrologic circumstances that impact out-migration?
Predation[36]	2	2	2	2	
water quality[37]	1	1	1	1	
	MARINE ENVIRONMENT				[38]Examine relationship between population fluctuations and environmental or human induced changes over time. [39]How many sockeye have been caught as a non-target species? What influence would this have on the population? Marine interception appears low based on their early run timing.
population trends: regional, large scale[38]	1	1	1	1	
interceptions (fish catch)[39]	1	1	1	1	
productivity of marine environment	2/3	2/3	2/3	2/3	
harvest	1	1	1	1	

Appendix B. Draft list of ranked research priorities by life cycle of lake Ozette sockeye:

Modified from the Lake Ozette Sockeye Habitat Technical Work Group
(Baseline data and limiting factors to accompany research priorities)

ADULT SOCKEYE ENTERING THE SYSTEM:

1. Cross bar (habitat, hydrology)
2. Predators (otters and seals; compare predation rates, scarring incidence, tagging, determine where predation occurs)
3. Water quality (temperature, dissolved oxygen)
4. Tidal prism (relationship with tidal influence)
5. Run timing and distribution (late April – mid August)
6. Run size
7. Ozette River habitat (width to depth ratio, past and present)
8. Stream flow

Adult Sockeye Entering the Ozette River

RANKED PRIORITY	LIFE CYCLE FACTOR	PLANNED/ CONDUCTED
1	Run size	Ongoing
2	Run timing and distribution	Ongoing
3	Predators	1998-2000+
4	Water quality and Ozette river habitat	1993-1994; historic reports
5	Cross bar, tidal prism	Aerial photos

PRIORITY JUSTIFICATION

1. Run Size: Determining the current run size and abundance trend of the four return year cycles of the sockeye population is critical to attaining recovery of Lake Ozette sockeye. Tracking population fluctuations over time will be a gauge to determine the success of restoration activities as well as the success of the overall Lake Ozette Sockeye Recovery Plan (Makah weir research). The 1999 abundance estimates yielded an adjusted count of ~2,076 adults. A strong year class is expected to represent the yr-2000 return based on the large return in 1996 (possibly more than 4,000 adults) and a large hatchery release from brood year 1996.
   -Observer vs. camera counts discussed (multiplying factor of 1.71).
2. Run timing and distribution : When are the sockeye returning to the system? Can a correlation be made between this timing and other activities etc. occurring in the system (Makah weir research)? Methods previously used to assess run timing may have apportioned a greater part of the run later in the season (Dlugokenski *et al.* 1981) than is currently measured by the underwater video camera. Either the methods projected run timing late or the inter-annual run timing has shifted earlier in recent years.

3. Predation: What type and to what extent are natural predators limiting sockeye from completing their life cycle?
   -NOAA observed low levels of mammalian predation near the river mouth (lower 300 m of river). NOAA and MFM may attempt to assess differential predation rates throughout the river and lake (NOAA and MFM research).
   Preliminary results from the weir indicated that 6% of adult sockeye contained visual scar marks (for 75% of the run). It was noted that the camera only viewed one side of the fish.
   -There were 264 total observations of otter at the weir through mid-July and 24 observations of seal from May to June.
4. Water quality: Is there evidence of anthropogenic impacts to water quality? If so, to what extent have any changes influenced migratory timing?
   -Variations in timing of spawning migrations may be in response to river flow and water temperature (flow and temperature as intensity factors of migration).

Priority 4 (continued)
-There is a relatively stable flow regime in Ozette River. Winter flows range from 10-28 cms and summer flows <9 cms (NPS data and Jacobs *et al.* 1996).
-Water temperature during mid-summer is generally greater than the preferred range for sockeye Literature indicates water temperatures > 18 C may be limiting to sockeye. The recommended water temperatures are 7.0 to 15.0 C for migratory adult sockeye.
Maximum daily water temperatures range from 7 to 24 C and are likely reflective of lake temperatures (> 20 C observed during a portion of the migration.
-Dissolved oxygen, pH, specific conductance, and turbidity do not appear to be limiting based on seasonal monitoring.
-There is an absence of historic water quality data for comparison.
-There are Ozette River habitat-cross sections of bridge 1912-1948.

5. Crossbar: Are there unique tidal prism influences that enhance or are detrimental to the sockeye life cycle (analyze sequential historic photos).
   -Has river hydrology changed?

ADULT SOCKEYE HOLDING IN LAKE:

1. Water quality (temperature, dissolved oxygen)
2. Predation
3. Population
4. Distribution, holding, mortality
5. Disease
6. Habitat characteristics
7. Kokanee and potential sockeye spawning aggregation impacts

Adult Sockeye in Lake Ozette

RANKED PRIORITY	LIFE CYCLE FACTOR	PLANNED/ CONDUCTED
1	Population, distribution, holding, habitat characteristics	Ongoing
2	Predation and disease	Ongoing
3	Water quality	1997

PRIORITY JUSTIFICATION

1. Population: Determining the abundance of the sockeye population and spawning aggregations, distribution, and where they hold within the lake will be important to understand behavior, habitat use, survival, and achieve recovery. Tracking the movement and habitat use of the overall population and of the different spawning aggregations over time will be a gauge to design restoration activities (Makah and NPS research).
2. Predation and disease: What impacts do these factors have on adult sockeye in the lake environment?
3. Water quality: Is there evidence of anthropogenic impacts to water quality in lake? If so, to what extent have any changes influenced adult holding? Is water quality changing over time?
   -Extensive monitoring of water quality occurred in the lake at four stations from 1993-1994.
   -Water temperature and dissolved oxygen did not appear to be limiting factors. The lake thermally stratified during summer months and an onset of mixing occurred in October. Surface water temperatures were 22 degrees celcius to 6 m depth during summer and dissolved oxygen was > 8 mg/l throughout the year.
   -pH ranged from 6.7 - 7.0 and declined with depth. pH was low in the summer and higher in winter.
   -Turbidity was extremely high after storm events (November: 161 to 185 NTU). There was a turbidity plume in the lake that extended to a depth of 13 m. At high levels, there would be a possibility of gill damage or possibly mate selection and spawning success could be impaired.

ADULT SOCKEYE SPAWNING ON BEACHES:

1. Number and distribution
2. Predation (NOAA and MFM research)
3. Suitable substrate quantity and quality (location of spawning beaches, potential spawning beaches)
4. Water quality
5. Habitat (suitability of vegetation and sediment)
6. Sex ratio; fecundity, age
7. Morphology
8. Possible interactions between sockeye and kokanee (stray rates, genetic analyses)
9. Natural spawning aggregations (stray rates, genetic analyses)

Adult Sockeye Spawning in Lake Ozette

RANKED PRIORITY	LIFE CYCLE FACTOR	PLANNED/ CONDUCTED
1	Number, distribution, sex ratio of total population and spawning aggregations	Ongoing
2	Suitable substrate, habitat characterization	Ongoing
3	Predation	Ongoing
4	Water quality	1997

PRIORITY JUSTIFICATION:

1. Abundance and distribution: There is a lack of information on the abundance and distribution of spawners along the Lake Ozette shoreline (Makah and NPS research).
2. Suitable substrate: An analysis of the substrate from core samples taken from mapped spawning beaches in 1999 by MFM is near completion. The size of aggregate present on mapped spawning beds and the size preferred by spawners in mapped areas utilized by spawners is being matched from the 1999 scuba spawning surveys on lake beaches by MFM.
3. Predation: Little is known about predation of adult sockeye in Lake Ozette. Adults spend a 6+ month period in the lake. This is a substantial amount of time when little is known about mortality. Heavy seal activity was observed on both spawning beaches in 1999 and seal predation of spawners has been observed in the past.
4. Water quality: Is there evidence of anthropogenic impacts to water quality in the lake? If so, to what extent have any changes influenced adult holding? Is water quality changing over time (NPS data)?
   -Data is not available for shoreline habitats (water temperature and intra-gravel dissolved oxygen.
   -There are elevated turbidity levels during storm events.

EGG INCUBATION IN LAKE:

1. Egg predation (during and after spawning)
2. Gravel quality and quantity (suitable substrate)
3. Habitat suitability (upwelling/springs)
4. Fertilization mortality rates
5. Change in lake water levels (8 feet per year)
6. Water quality (temperature, dissolved oxygen)
7. Changes in sedimentation, turbidity
8. Incubation duration
9. Outside chemical influence

Sockeye Eggs and Incubation

RANKED PRIORITY	LIFE CYCLE FACTOR	PLANNED/ CONDUCTED
1	Suitable substrate, habitat, changes in sedimentation, turbidity	ongoing
2	Egg to hatching survival	2000+
3	Egg predation	2000+
4	Lake levels	1997

PRIORITY JUSTIFICATION

1. Suitable substrate, etc: (What spawning beaches are utilized, what type of habitat is utilized, what is substrate composition? Determine habitat characteristics, substrate used during the incubation period. All viewed as critical for reproductive success.
2. Egg to hatching survival: Critical data gaps exist on early life history survival. What is egg to hatching survival? Are there fertility issues?
3. Egg predation: To what extent is predation impacting early life history (i.e. natural predation such as sculpin, peamouth, cutthroat trout, coho, or introduced predators such as perch and largemouth bass, mergansers and other piscivorous birds?
4. Lake levels: Influence of fluctuating lake levels or evidence of anthropogenic impact related to lake level. -The lake level may vary as much as 8 feet annually. This may impact the beach spawning areas.

FRY EMERGENCE IN LAKE:

1. Predator biomass and predation rate estimates
2. Mortality
3. Food Availability
4. Migration

Sockeye Emergence

RANKED PRIORITY	LIFE CYCLE FACTOR	PLANNED/ CONDUCTED
1	Predation	2000+
2	Food availability	2000+
3	Migration	2000+

PRIORITY JUSTIFICATION

1. Predation: Cursory evidence suggests that sockeye fry are preyed upon by coho and sculpin. To what extent is unknown (biomass studies required). Other possible predators of sockeye fry include yellow perch and cutthroat trout.
2. Food availability: Is proper size and type of zooplankton available for swim up sockeye fry in Lake Ozette during their emergence period?
3. Temporal and spatial distribution of fry remains unknown.

ADULT SOCKEYE ENTERING TRIBUTARIES:

1. Predation
2. Population and distribution within and among streams
3. Water quality
4. Competition and interaction with kokanee
5. Flow rates
6. Habitat Characteristics

Tributary Sockeye Adults

RANKED PRIORITY	LIFE CYCLE FACTOR	PLANNED/ CONDUCTED
1	Population and distribution	Ongoing
2	Water quality	Ongoing
3	Habitat characteristics	Ongoing

PRIORITY JUSTIFICATION
1. Population and distribution: Distribution and relative abundance of tributary spawners (NOR's and hatchery returns) continues to be monitored (MFM).
2. Water quality: Are there water quality issues unique to the spawning tributaries that would make them ultimately more or less viable to survival of the fry (variety of thermograph sites; turbidity)?
3. Habitat characteristics: Are there unique tributary features of the areas being utilized. Could land-use over time have altered this habitat in a manner that would have impacted sockeye use?

ADULT SOCKEYE SPAWNING IN TRIBUTARIES:

1. Redd count
2. Population
3. Distribution (both redds and fish)
4. Predation
5. Quality, quantity, and suitability of spawning substrate (scouring, fine sediment levels)
6. Water quality
7. Flow
8. Chemical influence
9. Habitat quality and quantity
10. Morphology (sex ratio, size, truss measurements, genetic variation)
11. Interaction between sockeye and kokanee

Tributary Sockeye Spawners

RANKED PRIORITY	LIFE CYCLE FACTOR	PLANNED/ CONDUCTED
1	Redd count, population, distribution, morphology, interrelationship with sockeye and kokanee	Ongoing
2	Substrate suitability quality and quantity, habitat quality and quantity	On going
3	Water quality, flow, chemical influence	Ongoing
4	Predation	?

PRIORITY JUSTIFICATION
1. Redd count, etc.: Distribution and relative abundance of tributary spawners (NOR's and hatchery returns) continues to be monitored (MFM). Continue to measure spawner replacement rates of NOR and hatchery returns. Are tributary spawners uniquely different from beach spawners? Continue to enumerate sympatric spawning among kokanee and sockeye, if observed.
2. Substrate suitability, etc.: What type and how much spawning substrate is available to the sockeye in the

tributaries. Continue to characterize tributary habitat (MFM).
3. Water quality, etc.: Are there unique water chemistry profiles that encourage/discourage tributary use? What type of hydrology suits spawning sockeye? (various thermograph sites)
4. Predation: Determine impact of predation on sockeye tributary spawners. What are the circumstances and the overall impacts to the spawning aggregation?

EGG INCUBATION IN TRIBUTARIES:

1. Egg predation (during and after spawning)
2. Gravel quality and quantity
3. Habitat suitability (upwelling/springs)
4. Fertilization mortality rates
5. Change in lake water levels (8 feet per year)
6. Water quality (temperature, dissolved oxygen)
7. Changes in sedimentation, turbidity
8. Incubation duration
9. Outside chemical influence
10. Tributary scour, fine sedimentation

Tributary Eggs and Incubation

RANKED PRIORITY	LIFE CYCLE FACTOR	PLANNED/ CONDUCTED
1	Egg to emergent survival, predation, sedimentation, scour, fertilization mortality	Ongoing
2	Gravel quality and quantity, habitat suitability	Ongoing
3	Water quality, incubation duration	Ongoing

PRIORITY JUSTIFICATION
1. Egg to emergence survival: What percent of the eggs survive to the outmigrant fry stage? What types of habitat issues impact this survival?
2. Gravel quality, etc.: What is the preferred spawning substrate for optimal egg survival. Are these incubation areas also utilized by other species that would result in a detrimental effect to sockeye? How much and where is this habitat available? Is it being utilized?
3. Water quality, etc: Are there water chemistry and hydrology factors occurring in the tributaries that could impact hatching success? Are there variables that impact egg incubation?

FRY EMERGENCE IN TRIBUTARIES:

1. Predation
2. Mortality
3. Food Availability
4. Migration

Tributary Emergence

RANKED PRIORITY	LIFE CYCLE FACTOR	PLANNED/ CONDUCTED
1	Migration	Ongoing
2	Predation	Ongoing
3	Food availability	2000+
4	Mortality	Ongoing

PRIORITY JUSTIFICATION
1. Migration: Where are fry migrating to and how long and under what circumstances are they migrating?
2. Predation: What unique circumstances are the fry encountering on their travels to the lake? What percentage of

this aggregation is successful on this migration?

3. Food availability: What are sockeye fry consuming and where? What is the preferred diet and to what extent is it available in the system? What other fish, etc., are also seeking out this food source?
4. Mortality: How successful is sockeye productivity through emergence? What percentage of the eggs hatch? Is this comparable with same species in other stream environments or different species in the same environment?

PELAGIC ENVIRONMENT:

1. Predation
2. Food availability

Pelagic Environment

RANKED PRIORITY	LIFE CYCLE FACTOR	PLANNED/ CONDUCTED
1	Predation	
2	Food availability	

PRIORITY JUSTIFICATION

1. Predation: What predators impact the juvenile sockeye population in Lake Ozette? What percentage of the juvenile population survives this predation? Are the predators introduced or naturally occurring in this system?
2. Food availability: What are the juveniles consuming in the lake environment? How available is this food? What is the competition for this food? Does it vary with seasonal changes?

JUVENILE OUT-MIGRATION:

1. Population
2. Predation
3. Water quality

Juvenile Out-migration

RANKED PRIORITY	LIFE CYCLE FACTOR	PLANNED/ CONDUCTED
1	Population	2000+
2	Predation	2000+
3	Water quality	Ongoing

PRIORITY JUSTIFICATION

1. Population: What proportion of NOR and hatchery lake- and tributary-origin smolts survive to out-migration?
2. Predation: What predator circumstances do the juveniles encounter during outmigration? What type of impact does this have on the population?
3. Water quality: Are there unique water chemistry and hydrologic circumstances that impact outmigration?

MARINE ENVIRONMENT:

1. Population trends (regional and large scale). What is the ocean survival rate of smolt outmigrants?
2. Productivity of marine environment
3. Harvest

Marine Environment

RANKED PRIORITY	LIFE CYCLE FACTOR	PLANNED/ CONDUCTED
1	Population trends	2000+
2	Productivity of marine environment	2000+
3	Harvest	2000+

PRIORITY JUSTIFICATION

1. Population trends: What is the smolt to adult survival rate? How has marine survival varied over time? Can environmental- or human- induced changes over time be correlated with population abundance variations?
2. Productivity of marine environment: How successful are the sockeye in the marine phase of their life cycle? What are they eating and how available is it? Do they share this food source with other species?
3. Harvest: Historically, what volume of sockeye was harvested? What percentage of these fish were Lake Ozette sockeye? How many sockeye have been caught as a non-target species? What influence did this have on the population?
   -Marine interception of Lake Ozette sockeye appears to be low based on their early run timing in relation to the opening of fisheries off of Vancouver Island.

Appendix C. Ecological interactions (from Section 2.5)

Describe salmonid and non-salmonid fishes or other species that could (1) negatively impact program; (2) be negatively impacted by program; (3) positively impact program; and (4) be positively impacted by program. Give careful considerations to the unlisted but listable indigenous species.

Salmonids that could negatively impact this program:

1. Kokanee salmon (Oncorhynchus nerka)
Origin: native species
Distribution: Lake Ozette, tributaries
Overlap with Ozette sockeye:
Adults: Adult spawners are present from both anadromous and resident species in the lake and in tributaries overlapping from November to January. Beauchamp *et al*. (1995) roughly estimated that 7,500 kokanee may spawn in the tributaries annually. Sexually mature kokanee and sockeye salmon have been observed on spawning beaches in Lake Ozette (Bill Mahone, personal communication).
Juveniles: Juveniles of both species have extensive overlap beginning when emerging fry initiate their stream outmigration and their emigration to offshore pelagic habitat in March annually. Interspecific interactions likely occur in offshore habitats that are heavily used by age 0 and age 1 Ozette sockeye, which mix extensively with kokanee of the same age up to three-to four-year-old kokanee. Results from past hydroacoustic surveys estimated that of the total offshore fish abundance estimate (439,000), approximately 395,000 (90%) were kokanee and sockeye (Beauchamp *et al.* 1995).

Negative impact: Hybridization. Lake Ozette sockeye and kokanee spawning aggregations are thought to originate from stocks which are highly divergent, and studies have indicated that hybridization between sockeye and kokanee may reduce the number of viable embryos, saltwater adaptability, and ocean survival. Alternatively, if hybrids do survive to adulthood and stray back to the lake beaches, the possibility of introgrssion with genetically disimilar, protected beach aggregations poses a different risk. These risks have been considered, and efforts are underway to genetically characterize the spawning aggregations and determine baseline genetic profiles for both species spawning aggregations and determine if a baseline level of hybridization can be detected. Hybridization in tributaries to Lake Ozette is a significant concern since kokanee are known to utilize some tributaries in high numbers. Because of this, Makah Fisheries Management has limited tributary sockeye reintroduction to Umbrella Creek and Big River, which are both known to have very low numbers of kokanee-sized fish and little or no spawning aggregations of kokanee. The lack of kokanee in these streams may be due to the larger size of spawning gravel aggregate in Umbrella Creek and Big River as compared to the pea gravel-sized aggregate typical of heavy kokanee producing streams such as Siwash Creek. Also, tributary program release strategies were changed from lake releases to direct releases into the target release stream, which has recently been shown to reduce or eliminate straying of tributary – origin adults back to the lake beaches.

Kokanee-sockeye interactions will be monitored during spawning surveys and through genetic analyses. If significant hybridization is detected in any supplementation strategy, that strategy will be discontinued. Since stray rates are low or zero and hybridization is low or zero, the risk of introgression back to the lake beaches is thought to be very low. Regardless, brood stock and carcasses recovered from the beaches will be assayed for kokanee genes as previously described (Attachment 2).

Negative Impact: Competition. Despite the high potential for dietary overlap with Lake Ozette sockeye, it is unlikely that sockeye abundance is affected by competition for food with kokanee. Although both species feed almost exclusively on large Daphnia (*Daphnia pulicaria*), both species combined consume less than 1% of the instantaneous production and standing stock (Beauchamp *et al.* 1995). The exceedingly large smolt size of Lake Ozette sockeye is further evidence that juvenile sockeye are not limited by competition (Dlugokenski *et al.* 1981). Based on seven different years of monitoring smolt size (MFM unpublished data; Jacobs *et al.* (1996), and an additional year of monitoring by Dlugokenski *et al*. (1981), the average fork length of Lake Ozette sockeye smolts is approximately 12 cm and average weight consistently exceeded 14 grams (and commonly exceeded 17 grams). These smolts were reported by Dlugokenski *et al*. (1981) to be the third largest sockeye smolts reported in the literature, exceeded only by Lake Dalnee, Kamchatka, Alaska, and Lake Washington sockeye. The exceedingly large size of Lake Ozette sockeye smolts relative to other sockeye smolts was previously reported in the literature. Burgner (1987) reported comparitive size data for sockeye smolts in 34 lake systems and reported average length and weight to be 8.9 cm and 7.5 grams, respectively.

Negative impact: Disease. Ozette sockeye and kokanee are known to be susceptible to IHN virus and Renibacterium salmoninarum, the causative agent of bacterial kidney disease (BKD). The incidence of infectious fish pathogens in pelagic kokanee and in juvenile sockeye should be studied to evaluate the potential for transmission of these pathogens to sockeye.

<u>2. Lake Ozette sockeye salmon (*Oncorhynchus nerka*)</u>
Origin: native species
Distribution: Lake Ozette and tributaries.
Overlap with supplemental Lake Ozette sockeye:
Adults: Adult hatchery returns and wild aggregations of adult spawners are both present in the lake and in Umbrella Creek from November to January each year.
Juveniles: Juveniles from supplementation and beach spawning aggregations are thought to have extensive overlap beginning when emerging fry begin their emigration to offshore pelagic habitat in March annually. Interspecific interactions probably occur in offshore habitats that are likely used by age 0 and age 1 supplementation - and natural - origin Ozette sockeye.

Negative impact: Competition. It is unlikely that supplemental sockeye abundance would be affected by competition for food with beach-origin Lake Ozette sockeye because plankton stocks in the lake are barely impacted by the current annual projected biomass of nearly 400,000 *Oncorhynchus nerka* (see kokanee above for more information).

Negative impact: Disease. Lake Ozette sockeye are known to be susceptible to IHN virus and Renibacterium salmoninarum, the causative agent of bacterial kidney disease (BKD). The incidence of infectious fish pathogens in pelagic progeny of beach spawners and supplemental-origin juvenile sockeye should be studied to evaluate the potential for disease transmission. However, the potential of natural spawners to infect hatchery-origin juveniles is highly unlikely because both species are exposed to the same water although hatchery-origin fish may have a higher predisposition to disease due to confinement, stress, or other conditions related to the artificial environment.

<u>3. Coho salmon (*Oncorhynchus kisutch*)</u>
Origin: native species
Distribution: Lake Ozette, tributaries.
Overlap with Ozette sockeye:
Adults: Adult coho spawners enter the tributaries of Lake Ozette from mid-October through January annually (Washington Dept. Fish & Wildl. & W. Wash. Treaty Indian Tribes 1994). Lake Ozette sockeye have been reported to spawn in the lake and tributaries from mid-October to March annually although no spawning has been observed after December in recent years. Both species are present in the tributaries from November through January. Adult coho were surveyed in nine different survey reaches within tributaries to Lake Ozette between October 27, 1998, and January 26, 1999, By Makah Fisheries Management (Table 22). Prior to these efforts, no systematic coho stock assessment work had been

conducted in this watershed in many years. Adult coho counts peaked at 200 fish per mile surveyed between December 3, 1998, and December 10, 1998.

Using the channel stratification system developed by the Strait of Juan de Fuca Work Group, field-verified, continuous habitat data has been completed by Makah Fisheries Management, as of September 1999, for all of Umbrella Creek, the mainstem of Big River, a portion of the tributaries to Big River, and large portions of the mainstem, North, and South forks of Crooked Creek. Bank full width, gradient, confinement, wetted width, pool number, length, residual and maximum pool depth, gravel quantity and quality (percent fines), number, size and channel position of all large woody debris, and biological impacts are being verified and recorded for all streams greater than 2.5 meters bank full width. Habitat classification, combined with increased effort by increasing the number of stream surveyors in 1999 and increasing the number of stream segments to ten per tributary, will enable very accurate escapements to be determined for these tributaries beginning in 1999. Estimates of the total coho spawning aggregation in the Ozette watershed are not available yet; both the peak counts from spawning surveys (below) and the juvenile outmigration data (Figures 16 and 17) indicate the existence of a substantial spawning aggregation. Systematic spawner surveys for Lake Ozette coho will continue as part of the regular stock assessment schedule conducted by MFM, with the intent of developing annual coho escapement estimates for the watershed.

Table 22. 1998/1999 adult coho spawner surveys conducted by MFM in the Ozette Basin.

Stream Name	Upper RM	Lower RM	Survey Length (Miles)	Number of Surveys	Peak Count	Peak Count/Mile	Date
Umbrella	3.50	2.50	1.00	4	24	24	12/03/1998
Umbrella	4.60	3.50	1.10	5	13	12	12/16/1998
Big River	9.50	7.10	2.40	7	104	43	12/09/1998
Big River	7.10	4.50	2.60	7	31	12	01/07/1999
Boe Creek	0.55	0.15	0.40	3	78	195	12/02/1998
Boe Creek	1.10	0.55	0.55	3	110	200	12/10/1998
Boe Creek	1.35	1.10	0.25	1	17	68	12/03/1998
Unnamed Trib. To Boe Creek	0.15	0.00	0.15	1	8	53	12/03/1998
Solberg Creek	1.00	0.00	1.00	3	16	16	12/02/1998

At present, management objectives for Lake Ozette coho have not been defined. No freshwater fisheries are directed at adult Ozette coho, and ocean fisheries are regulated to address the conservation and allocation needs of other coastal natural stocks. Since substantial numbers of spawners were observed in 1998, and since both ocean and freshwater harvests have been regulated in order to maintain stable escapements of other north coastal stocks, it is unlikely that current harvest levels are excessive for supporting stable natural production. There are no releases of hatchery coho in the Ozette watershed.

Juveniles: Emigrating juveniles pass through the lake in the spring. A smolt trap in the Ozette River in 1992 yielded a peak catch of coho smolts in early May (unpubl. Report from B. Conrad, NWIFC, to D. Drange, Makah Fish. Mgmt. 1993). Lake Ozette sockeye smolts, enumerated with a smolt trap in 1982, 1989, and 1990, had their peak outmigration through the Ozette river in late-May (MFM unpublished data).

Fyke netting, conducted by MFM at RM 1 in Umbrella Creek from 14 April through 27 May, 1999, recorded nearly 50,000 coho fry moving downstream into the lake (Figure 16). Daily counts peaked near the third week of April 1999 exceeding 6,000 swim up coho fry outmigrants per day (Figure 17). This lake resident juvenile life history pattern for coho salmon was not documented prior to this study. Since there are more coho in the Big River system than in Umbrella Creek (Table 22), it is assumed that several hundred thousand coho fry reared in Lake Ozette from this spring 1999 outmigration. Indeed, snorkel surveys found large numbers of coho fry residing along shoreline areas of the lake. It was estimated that at least as many fry remained in the tributaries, demonstrating a second riverine juvenile life history strategy for Ozette coho. Overall, a substantial juvenile coho population was observed in 1999 in consideration that nearly 60,000 outmigrating fry were enumerated in Umbrella Creek despite missing large numbers of outmigrants due to flooding, not counting the large numbers of fry in tributaries other than Umbrella Creek, nor enumerating the large number of coho fry that remained as stream residents in Umbrella Creek.

Negative impact: Predation. As previously mentioned, substantial numbers of coho fry were enumerated migrating into Lake Ozette from Umbrella Creek in the spring and summer of 1999. Significant numbers of fry were subsequently counted in lacustrine nearshore habitat. During enumeration efforts, coho fry (swim up to < 1 gram) and smolts were observed on several instances either eating, attempting to swallow, or attacking both live and dead sockeye fry inside the trap livebox. These observations indicate that coho predation may be a significant factor affecting sockeye fry survival due to the disproportionate abundance and temporal overlap of the two species. This overlap, which was not previously documented, likely occurs through smoltification in Lake Ozette, which would increase the potential of coho predation of sockeye during their freshwater residence. Further studies of coho predation on sockeye fry are sorely needed. Past studies did not mention any lake life history form of coho nor have any studies documented coho predation of sockeye in Lake Ozette or its tributaries.

Negative impact: Competition. Juvenile coho usage of the lake as rearing habitat is in need of further study; however, juvenile coho feed primarily on zooplankton and emerging insects in lake and reservoir environments (Wydoski and Whitney 1979), so there is potential competition for food. However, there is no indication that food availability is a limiting factor affecting sockeye salmon production in Lake Ozette (see kokanee, above).

Negative impact: Disease. Ozette sockeye and coho salmon are known to be susceptible to BKD. Some coho populations in Oregon have been found to have a very low incidence of non-clinical IHNV pathogen. The potential for disease transfer among juvenile coho and sockeye has not been studied to our knowledge.

4. Cutthroat trout (*Oncorhynchus clarkii*).
Origin: native species
Distribution: Lake Ozette, tributaries.
Overlap with Ozette sockeye:

Adults: Cutthroat are thought to spawn in tributaries to Lake Ozette in late winter, but spawning data is lacking for this species. Ozette sockeye spawn in the lake and tributaries from November to reportedly as late as March annually. Cutthroat trout are present during spawning and egg deposition on lake beaches from October through February annually. Cutthroat trout have been observed with juvenile sockeye in nearshore and offshore areas during the entire freshwater rearing cycle (Dlugokenski *et al.* 1981; Beauchamp *et al.* 1995). A 13-inch cutthroat trout, captured by gillnet on 11/29/00 on Olsen's Beach, was found to be gorged with sockeye salmon eggs (MFM unpublished field notes, 2000).

Negative Impact: Predation. Although cutthroat trout captured in nearshore areas were found to consume sockeye fry, Beauchamp *et al.* (1995) clarified that there is no evidence that cutthroat trout consume large numbers of juvenile sockeye during their nearshore residence; however, cutthroat trout have been observed to consume large numbers of eggs on spawning beaches (Dlugokenski *et al.* 1981; MFM unpublished field notes, 2000). Beauchamp *et al.* (1995) suggested that this species could exert considerable control over sockeye salmon abundance due to offshore predation where 40% of the diet of large cutthroat trout was found to consist of age 0 and age 1 sockeye salmon and kokanee. Beauchamp *et al.* (1995) estimated that for every 1,000 cutthroat trout greater than 300 mm, 138,900 age-0 and 27,000 age-1 *O. nerka* are consumed. Biomass estimates of cutthroat trout remain unstudied in Lake Ozette, although Beauchamp *et al.* (1995) speculated that the population of large cutthroat was between 5,000 and 10,000 fish.

Negative impact: Disease. We are unaware of any documented disease transmission from cutthroat trout to sockeye salmon. However, the incidence of infectious fish pathogens in cutthroat trout should be examined and the potential for transmission to sockeye should be evaluated if any are detected.

5. Rainbow trout and steelhead (*Oncorhynchus mykiss*)
Origin: native species
Distribution: Lake Ozette, tributaries.
Overlap with Ozette sockeye:

Adults: Adult winter run steelhead migrate through the Ozette River and Lake Ozette to the tributaries from December through May annually with spawning occurring from mid-February to early-June. Adult rainbow trout inhabit the lake and it's tributaries.
Juveniles: Juvenile steelhead reside for two years in the lake and tributaries before the smolt outmigration in late spring to early summer. Juvenile rainbow trout inhabit the lake and tributaries. Small numbers of 0+, 1+, and 2+ steelhead fry and smolts were also trapped by fyke net in the spring of 1999 (MFM unpublished data).
Potential negative impact: Neither life history form of this species is currently regarded as a major competitor nor a predator of sockeye salmon.
Negative impact: Disease. Ozette sockeye and rainbow trout are known to be susceptible to infectious hematopoietic necrosis (IHN) virus. The incidence of infectious fish pathogens and the potential for disease transmission among pelagic juvenile sockeye, rainbow, and steelhead trout has not been studied.

Non-salmonid fishes that could negatively impact this program:

1. Northern squawfish (*Ptychocheilus oregonensis*)
Origin: Unknown.
Distribution: Ozette River, Lake Ozette, and tributaries.
Overlap with Ozette sockeye:
Adults: Northern squawfish are abundant in the Ozette River and in Lake Ozette. Squawfish occur in nearshore and offshore zones where they interact with juvenile sockeye during their entire freshwater rearing cycle.
Negative impact: Predation. Similar to cutthroat, squawfish have not been found to prey on sockeye juveniles in nearshore areas (Dlugokenski *et al.* 1981; Beauchamp *et al.* 1995). However, Beauchamp *et al.* (1995) found that large squawfish in offshore areas consumed sockeye and kokanee salmon. For every 1,000 squawfish exceeding 300 mm, 5,600 age-0 sockeye and kokanee salmon may be consumed per year (Beauchamp *et al.* 1995). Biomass estimates of squawfish are also lacking in Lake Ozette. As with cutthroat trout, predation impacts by squawfish on Ozette sockeye abundance remain unknown due to the lack of abundance estimates. Adult squawfish have been observed attempting to prey on various salmon smolts in the vicinity of the adult weir in the Ozette River in recent years (MFM unpublished data).

2. Sculpin (*Cottus spp.*)
Origin: native

Distribution: Ozette River, Lake Ozette, and tributaries.
Overlap with Ozette sockeye: Sculpin have been hypothesized in the past to have little spatial or temporal overlap with juvenile Ozette sockeye. They typically inhabit pools and quiet water in large coastal streams, and shores of lakes. There is known temporal and spatial overlap with adult beach-spawners and with outmigrating juvenile sockeye fry in tributaries.

Negative impact: Prickly sculpin have been known to prey on eggs of sockeye salmon in Lake Ozette (Beauchamp and LaRiviere 1993). More than 200 sculpin were observed during fry fyke netting in Umbrella Creek, and many sculpin were observed during beach spawner surveys in Lake Ozette in 1999. Sculpin in Umbrella Creek appeared to selectively feed on swim up sockeye fry inside a livebox trap, independent of prey density (which was dominated by coho fry). This was postulated to be due to their inclination to hide motionless on the bottom substrate where the sculpin also resided. Total sockeye fry mortality due to fyke netting in 1999 exceeded 9%; however, more than 4% of these mortalities were recovered from the stomach contents of sculpins. These data indicate that predation on fry, as well as eggs, may have a negative impact on sockeye abundance.

3. Largemouth bass (*Micropterus salmoides*)
Origin: introduced
Distribution and negative impacts: Very little is known about this introduced species. Considering that it is a voracious predator and numerous enough in Lake Ozette to be commonly caught by recreational anglers, biomass estimates of this species, as well as predation rates on sockeye juveniles need to be determined.

4. Peamouth (*Mylocheilus caurinus*)
Origin: presumed native
Distribution: Lake Ozette and tributaries, possibly Ozette River.
Overlap with Ozette sockeye: Peamouth have little overlap with sockeye juveniles in nearshore habitats, and are much less abundant in offshore habitats of Lake Ozette (Dlugokenski *et al.* 1981, Beauchamp *et al*. 1995). Large schools of spawned out peamouth were observed on two occasions in late-spring of 1999 temporarily migrating upstream while conducting fyke netting in Umbrella Creek. No evidence of predation or any feeding was observed in stomachs and none of the fish examined were gravid. These large schools remained in the stream ranging from several hours to several days on two occasions during the summer of 1999 before rapidly outmigrating back to the lake (MFM unpublished data).
Negative impact: Peamouth eat some sockeye salmon eggs, but the extent of their egg predation is unknown (Jacobs *et al.* 1996).

Other species that could negatively impact this program:

1. River Otter (*Lutra canadensis*)
Origin: native
Distribution: Ozette River, tributaries, and lake.
Overlap with Ozette sockeye: There is extensive overlap between river otter and adult sockeye during the entire spring and summer migration into Lake Ozette (April through August).

Negative impact: Predation. In 1999, the estimated adult run size in the Ozette River was approximately 2,076 fish. River otters were observed on 274 occasions in 1999 in the Ozette River. Otters were directly observed predating on adult sockeye in 1998, 1999, and 2000. In 1999, VCR- taped footage recorded 10 instances of direct otter predation of adult sockeye which included footage on three occasions of adult sockeye being carried to and from Lake Ozette. Approximately 4.5% of the run had scar marks visible on one side of the fish, which were often severe. Visual observers documented 34 occasions when they could hear or see nocturnal otter predation occurring within 150 meters of the weir which included seven direct observations of river otters eating adult sockeye. Due to the limited field of vision of the camera, visual observers documented 2.7 times more direct predation by otters than did the video camera despite that the observers were only present at the river during evening hours (37.5% of the time). The Makah Tribe and the NMFS NMML staff are currently in the process of developing estimates of freshwater and ocean scarring incidence attributable to predation. The desired result from this research will be to estimate adult mortalities due to predation wounds and due to successful predation events to determine overall pinniped predation and pinniped-related predation mortality rates of adult Lake Ozette sockeye. This research should also help to determine what proportion of the trauma is attributable to which pinniped species.

Preliminary Analysis of river otter scat is underway for 1999 although scat analyses in 1998 did not reveal sockeye remains (Gearin *et al.* 1998; MFM unpublished data). However, Gearin *et al.* (1998) cautioned that this preliminary finding should not be used to judge potential impacts of otter predation on the run. Since the run is relatively small and is protracted over three to four months, it is unlikely that significant sockeye remains would be found in otter scat on the few occasions that samples were collected. Partial remains of adult sockeye were observed on the banks of the Ozette River in the summers of 1998 and 1999 with otter scat. Otter scat analyses in the future will focus on upper riverbank areas where nearly all of the otter predation has been observed to date.

Research in 2000 will focus on comparing the scarring incidence of adults captured at the river mouth upon entry from saltwater to the incidence of scarring at the head of the river as adults enter the lake at the weir. This will assist in determining where in the river the predation primarily occurs and by closely examining the scar marks, to determine the type of predator causing the injuries. Gearin *et al.* (1998) noted that river otter predation is a cause for concern because they are, "adept predators and are fully capable of preying on adult sockeye in the narrow and shallow water conditions in the upper river."

2. Harbor Seal (*Phoca vitulina*)

Origin: Native

Distribution: Ozette River and Lake Ozette

Overlap with Ozette sockeye: There is extensive overlap between harbor seals and adult sockeye during their entire migration up the Ozette River from April through late-July, during the adult sockeye lake holding period (primarily April through October) and particularly during spawning along the lake beaches (primarily November through December; but seals have been observed in the lake into March) annually.

Negative impact: Predation. Harbor seals migrate up the Ozette River into Ozette Lake and have been seen feeding on adult sockeye salmon in the river and off of the spawning beaches in Lake Ozette (MFM unpublished data; Gustafson *et al*. 1997; Gearin *et al.* 1998). Observations in the lower river during 1998 indicated that harbor seals entered the river frequently during high tide cycles thus overlapping the period of maximum sockeye passage into the Lake (Gearin *et al.* 1998). In 1999, intensive efforts were conducted at the river mouth by Gearin *et al.* (1998) to record predation and foraging behavior by seals and otters in this area. Although no predation was observed at the mouth, seals and otters frequented the area and were observed exhibiting foraging behavior in the area.

Camera data from the weir on the upper river recorded harbor seals swimming through the weir at least 20 times in 1999. Harbor seals were observed preying on sockeye salmon within 150 meters of the weir on five occasions by visual observers in 1999 (MFM unpublished data). Harbor seals were seen preying on adult sockeye during trapping operations in 2000 in the lower and upper Ozette River. On one occasion, a seal was observed climbing over the weir when water levels were high to enable entry into the lake when adult sockeye were also entering the lake. The usual weir opening was closed during trapping.

Harbor seals were observed by visual observers and by the underwater camera directly predating on sockeye in the Ozette River in 1998 and in 1999 with footage of adult sockeye in their mouths on both years (MFM unpublished data). This was determined by Gearin *et al.* (1998) as a, "cause for concern given the small size of the sockeye population because even a small number of seals could potentially consume a significant number of fish." Gearin *et al.* (1998) determined that in excess of 1,000 Harbor seals inhabited a 5.5 kilometer area from the river mouth and were observed entering the river in five out of nine days surveyed in 1999. The rate of seal predation appears to be related to river depth, which fluctuates with tidal changes in the lower river, and with the mean water surface elevation in Lake Ozette; dropping to nearly zero in the upper river by late summer (MFM unpublished data).

Seal predation on sockeye salmon on the spawning beaches appears to be an even greater problem. It is presumed that territorial spawners in shallow water near the shoreline may be highly susceptible to seal predation. National Park Service and MFM personnel have observed seals in the lake ranging from May through December in past years and seals have been observed chasing adult coho salmon up onto the lake shoreline. It is presumed that seals follow adult coho run into the lake when water levels are high in the fall and winter but it also appears that several individuals have learned the location of both beach spawning aggregations and have focused predation on beach spawning Lake Ozette sockeye.

Boat surveys were conducted bi-monthly in Lake Ozette during the spawning season from October through December in 1998 and weekly scuba surveys of the main spawning sites were conducted by Makah Tribe and Olympic National Park divers in 1999. These surveys documented the presence of harbor seals in Lake Ozette six times when single seals were observed. Seals were observed during the peak spawning season at both Allen's and Olsen's Beaches. The 1998 and 1999 investigations determined that harbor seals have a high degree of spatial and temporal overlap with Lake Ozette sockeye during the spawning season when adults are most vulnerable. Sockeye heads were recovered on nearly all surveys that were bitten off below the operculum. Other adult sockeye carcasses were found on lake beaches that presumably resulted from seal predation as evidenced by bite marks. Some of these fish were still ripe and had not yet spawned before their demise (MFM unpublished data). Further studies in 2000 and beyond will attempt to quantify predation losses by harbor seals and to determine where and when the predation occurs.

Harbor seal scat analyses (from saltwater haul out rocks) in 1998 did not reveal sockeye salmon remains (Gearin *et al.* 1998). However, Gearin *et al.* (1998) did not recover scat from seals in freshwater. A large amount of scat was observed by MFM scuba divers in early December of 1999 on the spawning substrate on lake beaches in conjunction with seal observations on both beaches but was diluted and lost due to a major flood before it could be collected. Further research will entail an examination of the scar wounds and scarring incidence in the river and a focused study of harbor seal predation on lake spawners (Attachment 1).

3. Stellar Sea Lion (*Eumetopias jubatus*) and California Sea Lion (*Zalophus californianus*)
Origin: Stellar Sea Lion (native), California Sea Lion (migratory)
Distribution: Ocean areas near Ozette River mouth. Stellar sea lion numbers were found to range from 404 to 1,016 individuals, and California sea lions were found to range from 0 to 541 individuals within approximately 18.5 kilometers from the Ozette River mouth by Gearin *et al.* (1998).
Overlap with Ozette sockeye: There is potential overlap between sea lions and Ozette sockeye during the ocean phase with particular potential for interaction between smolts and adults in saltwater areas near the river mouth where sea lion and sockeye numbers are highest.
Negative impact: Predation. Since no sea lions were observed in the Ozette River or in Lake Ozette and because no sockeye remains were found in scat collected from saltwater haul out areas, Gearin *et al.* (1998) concluded that interactions between Lake Ozette sockeye and sea lions are probably minimal. However, as much as a third of the adult run entering the Ozette River was found to be scarred in 2000 and many of the bites appeared to be older scars caused by sea lions as evidenced by bite radii (MFM and NMFS NMML unpublished data)

4. Common Mergansers (*Mergus sp.) and* Hooded Mergansers (*Lophodytes sp*.) have been observed eating salmon smolts in the Ozette River near the lake outlet (Dave Easton, ONP, personal

communication). Up to 20 mergansers were observed diving and feeding on salmon smolts and other unidentified fish species near to the mouth of the Ozette River in 1999 by NMML, NMFS personnel (Kirt Hughes personal communication).

5. Other avian predation: The extent of other avian predation upon sockeye in the Ozette system is not known; however, belted kingfishers (*Ceryle alcyon*), and bald eagles (*Haliaetus leucocephalus alascanus*) have been observed along the Ozette River (MFM unpublished data; Gearin *et al.* 1998).

Salmonids that could be negatively impacted by this program:

<u>1. Kokanee salmon (*Oncorhynchus nerka*)</u>
Origin: native species
Distribution and overlap: See above.
Negative impact: Hybridization. Lake Ozette sockeye and kokanee spawning aggregations are thought to originate from stocks which are highly divergent, and studies have indicated that hybridization between sockeye and kokanee may reduce fitness of both species or result in introgression among these highly distinct gene pools. These factors have been considered, and efforts are underway to genetically characterize the spawning aggregations and determine a baseline level of hybridization. Hybridization in tributaries to Ozette is a significant concern since kokanee are known to utilize some tributaries in high numbers. Because of this, Makah Fisheries Management has limited tributary sockeye reintroduction to Umbrella Creek and Big River, which are both known to have low numbers of kokanee. Stray rates from the tributary program have been low or zero which further reduces the risk of loss of fitness from potential hybridization. Kokanee-sockeye interactions will be monitored in spawner surveys and through genetic analyses as previously described in Attachment 2. If significant hybridization is detected in any supplementation strategy, that strategy will be discontinued.

Negative impact: Disease. Kokanee are known to be susceptible to IHN virus and BKD infection; however, transmission from hatchery releases is unlikely. The sockeye salmon supplementation project will be conducted using methods consistent with Pacific Northwest Fish Health Protection Committee (1989) and Salmonid Disease Control Policy of the Fisheries Co-Managers (1992) guidelines. These guidelines define incubation, rearing, sanitation, and fish health practices that minimize the potential for disease transmission, both within and outside of hatchery stocks. Evidence does not indicate routine disease transmission from hatchery to wild fish (Steward and Bjornn 1990). The incidence of infectious fish pathogens will be monitored in sockeye fry up through each release. Pathogen incidence in kokanee and in sockeye post-release should be evaluated when samples can be collected to determine the potential for disease transmission among these species.

Negative impact: Competition. Despite the high potential for dietary overlap with kokanee, it is unlikely that food availability is a limiting factor on production for either kokanee or sockeye in the Ozette system.

<u>2. Lake Ozette sockeye salmon: (*Oncorhynchus nerka*)</u>
Origin: native species
Distribution and overlap: See above.

Negative impact:: Hybridization. Two beach spawning aggregations of sockeye, the naturally spawning Umbrella Creek spawning aggregation, as well as a potentially distinct tributary spawning aggregation, which is more likely to be a product of previous reintroduction efforts by the Makah Tribe's Umbrella Creek Hatchery, comprise the overall Lake Ozette sockeye population. Genetic analyses are underway to determine whether these aggregations are indeed distinct. Brood stock have not been collected from Allen's Beach in recent years (since 1996). Beginning in 2000, small collections are proposed for adults on both lake beaches for experiments for non-lethal fin tissue sampling. If the lake spawning aggregations are determined to be distinct, supplementation efforts will take this into account in developing separate supplementation and reintroduction strategies. Utilization of Olsen's Beach brood stock for tributary supplementation has been discontinued and replaced by tributary brood stock collection beginning in 2000. Baseline genetic data is being collected, and future activities will monitor genetic interaction between any identified subpopulations. Supplementation strategies which result in unacceptable levels of hybridization will be avoided. Since straying from Umbrella Creek tributary spawners to lake beaches is low or zero, the risk of introgression of supplemental fish with beach aggregations is very low.

Negative impact: Disease. Lake Ozette sockeye are known to be susceptible to IHN virus and BKD infection; however, it is unlikely that supplementation sockeye will adversely impact the lake spawning aggregations. Our supplementation project will be conducted using methods consistent with Pacific Northwest Fish Health Protection Committee (1989) and Salmonid Disease Control Policy of the Fisheries Co-Managers (1992) guidelines. These guidelines define incubation, rearing, sanitation, and fish health practices that minimize the potential for disease transmission, both within and outside of hatchery stocks. Furthermore, evidence does not indicate routine disease transmission from hatchery to wild fish (Steward and Bjornn 1990). All supplementation stocks will be tested for pathogens. Pathogens occurring in hatchery stocks most likely will be endemic to the wild stock as well. While amplification is possible in the hatchery, the previously mentioned procedures are designed to reduce the risk of transmission. Eggs are disinfected in 100 ppm iodophor and isoincubated. Releases will consist of healthy, eyed eggs, which have little propensity as a vector for disease transmission. Only healthy fry will be released. The incidence of infectious fish pathogens in kokanee and in supplemental and lake aggregations of sockeye following release needs further study to evaluate the potential for disease transmission among these species.

Negative impact: Competition. Despite the high potential for dietary overlap, it is unlikely that natural Ozette sockeye abundance will be affected by competition for food with supplemented sockeye due to the ample food supply in Lake Ozette.

<u>3. Coho salmon (*Oncorhynchus kisutch*)</u>
Origin: native species
Distribution and overlap: See above.
Negative impact: Disease. Coho salmon are known to be susceptible to BKD infection and a few coho populations in Oregon have tested positive for non-clinical IHNV pathogen. Evidence does not indicate routine disease transmission from hatchery to wild fish (Steward and Bjornn 1990). However, the incidence of infectious fish pathogens in sockeye following release should be evaluated to the extent possible to evaluate the potential for transmission of pathogens to coho.

<u>4. Cutthroat trout (*Oncorhynchus clarkii*).</u>
Origin: native species.
Distribution and overlap: See above.
Negative impact: Disease. Although the discharge of hatchery effluent and interactions between supplemented sockeye and cutthroat have the potential to transmit fish pathogens, we are unaware of any documented disease transmission from sockeye salmon to cutthroat trout. The sockeye salmon supplementation project will be conducted using methods consistent with Pacific Northwest Fish Health Protection Committee (1989) and Salmonid Disease Control Policy of the Fisheries Co-Managers (1992) guidelines. These guidelines define incubation, rearing, sanitation, and fish health practices that minimize the potential for disease transmission, both within and outside of hatchery stocks. Evidence does not indicate routine disease transmission from hatchery to wild fish (Steward and Bjornn 1990). However, the incidence of infectious fish pathogens in sockeye following release should be evaluated to the extent possible to evaluate the potential for transmission of pathogens to cutthroat trout.

5. Rainbow trout and steelhead (*Oncorhynchus mykiss*)
Origin: native species
Distribution and overlap: See above.
Negative impact: Disease. Rainbow trout are known to be susceptible to IHN virus infection. However, increased disease frequency is not expected. The sockeye salmon supplementation project will be conducted using methods consistent with Pacific Northwest Fish Health Protection Committee (1989) and Salmonid Disease Control Policy of the Fisheries Co-Managers (1992) guidelines. These guidelines define incubation, rearing, sanitation, and fish health practices that minimize the potential for disease transmission, both within and outside of hatchery stocks. Evidence does not indicate routine disease transmission from hatchery to wild fish (Steward and Bjornn 1990). However, the incidence of infectious fish pathogens in sockeye following release should be evaluated to the extent possible to evaluate the potential for transmission of pathogens to rainbow trout.

Non-salmonid fishes that could be negatively impacted by this program:

1. Northern squawfish (*Ptychocheilus oregonensis*)
Origin, distribution, and overlap with Ozette sockeye: See Above
Negative impact: No negative impact is expected. Squawfish may feed on hatchery fish to a small extent, which could reduce the pressure of squawfish predation on natural aggregations of Ozette sockeye and kokanee.

2. Sculpin species (*Cottus spp.)*
Origin, distribution, and overlap with Ozette sockeye: See Above
Negative impact: No negative impact is expected. Hatchery supplementation efforts will not significantly affect the habitat or food availability for sculpin.

3. Largemouth bass (*Micropterus salmoides*)
Origin, distribution, and overlap with Ozette sockeye: See Above
Negative impact: No negative impact is expected. Hatchery supplementation will reduce the impact of largemouth bass predation on natural aggregations of Ozette sockeye and kokanee.

4. Peamouth (*Mylocheilus caurinus*)
Origin, distribution, and overlap with Ozette sockeye: See Above
Negative impact: No negative impact is expected. Hatchery supplementation of the natural population is expected to reduce the impacts of egg predation by this species.

5. Redside shiner (*Richardsonius balteatus*)
Origin: Native
Distribution: Lake Ozette
Negative impact: No negative impact is expected. While sockeye and shiners are both planktivorous, plankton abundance is not considered to be a limiting factor on any species, nor is it expected to become a limiting factor in the future.

6. Threespine stickleback (*Gasterosteus aculeatus*)
Origin: Presumed Native
Distribution: Presumed Lake Ozette
Negative impact: No negative impact is expected. While populations of stickleback often have overlaps in diet and distribution, the absence of data on this species suggests low stickleback abundance in Lake Ozette. Furthermore, interspecific competition is not perceived as a limiting factor for any planktivorous

species.

7. Yellow perch (*Perca flavenscens*)
Origin: Introduced
Distribution: Lake Ozette
Negative impact: No negative impact is expected. While juvenile yellow perch and juvenile salmon both utilize plankton as a food source, food availability is not perceived as a limiting factor for planktivores in Lake Ozette.

8. Olympic mudminnow (*Novumbra hubbsi*)
Origin: Presumed Native
Distribution: Lake Ozette, tributaries
Negative impact: No negative impact is expected. The Olympic mudminnow appears to be a nonselective feeder, and is not considered a major competitor with sockeye salmon.

Other species that could be negatively impacted by this program:

This program is not expected to have negative impacts upon other species. Precautions will be taken to ensure that supplementation efforts do not degrade the health of existing ecological relationships or native populations of flora and fauna. On the contrary, numerous species have already benefited from this program including the fish, mammals, and birds previously listed, including bears and eagles.

Appendix D. Potential methods for future beach collections and release strategies:

Once agreed numbers or percentages of brood stock are approved for collection from a particular beach spawning aggregation, an abundance-based collection strategy should be employed. One method proposed would utilize conservative catch, mark, and recapture limits to prevent over-collecting or over-handling beach spawners. While this method will continue to be open for discussion, we propose an annual future production target for lake reintroduction and supplementation in high abundance years (>1,200 adults) to collect no more than 25% of any beach spawning aggregation. When fish numbers are less than 1,200, a maximum of 10% of any beach spawning aggregation would be proposed (sex ratio of brood stock will always be 1:1). These are only target goals. Catch and recapture limits, and other monitoring as described below, will further restrict the number of fish that are actually collected.

Conservative catch and recapture methods applied in any future lake collection regime to abundance-based collection goals, future adult brood collections will be far more conservative than in previous years, and all progeny will be returned to the lake.

Adult brood stock would be collected from their source beach during a two-month period from October through December annually, when pre-spawning and ripe sockeye may be captured in the vicinity of their natural spawning grounds. Adult collections from lake beaches would occur in roughly seven-day intervals, modified as necessary for weather. If any green or ripe adults are captured outside of this window, they would also be collected relative to their abundance. The intent of this brood stock collection distribution is to ensure that no particular segment of the run is amplified with respect to run timing over other portions.

Although the following lake brood stock capture method may need to be refined, it was designed to ensure that spawning aggregations are never over-harvested and to describe the method that was employed in 1999:

During any particular brood stock collection, no more than 40% of the fish caught on a particular set from a given beach would be retained (randomly select and return six of each ten fish captured). A numbered, external tag will be given to all released fish and a fin clip will be excised from each for genetic analysis to identify any recaptures. If recapture rates exceed 25%, brood stock collection will be discontinued until the next collection period to avoid excessive harrassment or handling of beach spawners. No brood stock were recaptured in 1998 when brood stock collection efforts occurred in approximately 10-day intervals. In 1999, a total of 20/141(14%) were recaptured; however, most recaptures (16/20; 80%) occurred on one occasion when brood stock collection efforts were attempted twice within a two-day period.

The catch and recapture limits and methods described above were employed in 1999 and appeared to be too conservative because they required too much handling of other fish not retained in order to collect a very small number of brood stock. This method should be refined because it was only possible to collect 28 fish despite capturing a total of 121 different adult sockeye on Olsen's Beach.

Any ESA brood stock collection effort is expected to have some degree of harassment to the protected spawning aggregations, which could adversely impact spawning success or cause direct take; however, once spawning abundance can be more accurately assessed on lake beaches, single, discreet biweekly net captures of agreed numbers with 100% retention would minimize disturbance to spawners. Presuming that lake beach supplementation and/or reintroduction is proposed in the future, benefits such as increasing abundance, productivity, spatial distribution, and diversity of the ESU and addressing limiting factors must be weighed against the risk of doing nothing or against risks associated with genetic and ecological challenges related to supplementation of the donor spawning aggregation; or with risks related to collection of eggs for reintroduction to new lake beach sites.

Brood stock capture and transport mortality in the lake has been very low using these methods in the past. For example, in 1998, a total of 38 females and 49 males (87 fish total) were captured and transported to the Umbrella Creek Hatchery. There were a total of three male mortalities that occurred immediately during transport (3.4% capture, transport, and holding mortality). There were no other mortalities (including holding mortalities) prior to sacrificing fish for spawning the fish in 1998. In 1999, 1/29 (3.4%) brood stock died from capture through holding until spawning. Our transfer protocol limits us to ~ 30 fish per trip and a maximum of two trips per day.

The 40% catch retention rate proposed above for future collections on lake beaches is further restricted because it only applies to unmarked/unreleased fish. For example, if 100 fish are captured but 30 are marked recaptures, then only 40% of the 70 unmarked fish (or 28 fish) could be retained. In reality, the 40% catch retention limit does not in any way reflect 40% of the spawning aggregation, it is merely the maximum percentage of any given catch that may be retained. Under a scenario that would exceed the largest catches ever and greatly exceed the average catch, the 40% retention method might be used to collect ~ 20% as described below:

Catch #1:	150 fish (this exceeds the maximum number ever captured).
	60 fish retained (keep 40%)
	90 tagged
Catch #2:	100 fish (an infrequently high catch and higher than any second attempt catch)
	40 fish retained (keep 40%)
	60 tagged
Total Catch:	50 pairs (if no recaptures occurred)

Since spawner abundance is not normally distributed, actual catches will vary with spawner abundance throughout the beach spawning window, with the goal being to mimic brood stock collection proportionally to the temporal abundance and distribution observed of the natural spawners. This is accomplished by retaining a percentage of the catch, which is expected to vary directly with relative spawner abundance. Although green fish have been observed before the collection period and spawned out fish have been observed after the collection period, our best knowledge of the time and distribution when nearly-ripe fish are present on Olsen's Beach approximates a left-skewed bell shape curve from November through December each year.

When the total run size is high (>1,250), a maximum of 25% of a spawning aggregation may be collected; however, this target is subject to the previously described catch and recapture limits. When fish numbers are intermediate (ranging from 800 to 1,200), the plan calls for a reduction in the maximum brood stock collection from 25% to 10% of the spawning aggregation, and will, at a minimum, equally emphasize supplementation of the appropriate source beach and new beaches. When fish numbers are low (<800), maximum brood stock collection would again be 10% of the spawning aggregation, but with 100% of the egg take used to supplement the donor beach.

As previously stated, only lake stock would be used for lake supplementation and lake beach reintroduction projects. Tributary brood stock will be utilized only for tributary plants. The original draft of this plan proposed a maximum withdrawal of 40% of the total run size based on the Hood Canal Summer Chum Plan. This draft revises the maximum withdrawal based upon seasonal run size as previously described, never exceeds 25% of any spawning aggregation, and is subject to the catch limits and mark and recapture restrictions previously described. The Makah Tribe intends to keep the scale of any future lake brood stock takes low, and to otolith mark a sufficient number of hatchery fish (targeting 100%), which may then be subsequently monitored upon release.

If lake beach reintroduction and/or supplementation is approved in the future, brood stock may be captured separately from each of the known spawning beaches. Allen's Beach may remain a "no touch" zone or supplementation may be proposed, depending on results of limiting factors analyses and abundance and productivity estimates. Gillnets deployed by boat will be used to collect nearly ripe adults throughout the spawning run. The net will be deployed for brief, five- to ten-minute sets. Gill nets have been used instead of seines because capture mortality was previously observed due to seines because seines easily became hung up on large woody debris. This caused fish to be entrapped longer and exposed them to strong forces due to tension from the snagged net. Also, gill netting has been found to be preferable to seining because very low or no capture mortality has been observed using gill nets and because seining was observed to disturb spawning gravels. The 4.5" mesh has not been found to gill the fish but rather adult sockeye typically become tangled in the web or the mesh slips past the gills, usually ensnaring the fish at mid-body around the dorsal-ventral surfaces. The few fish that have become more tightly entangled during these brief sets have been easily broken free from the weak nylon mesh to prevent injury.

Captured adults will be temporarily held in floating totes and sex ratios, numbers clipped, tagged, and recapture rates will be recorded. The adult Lake Ozette sockeye will then be transported in fish tanks under oxygen by boat for approximately 30 minutes to Umbrella Bay and then by truck under oxygen for approximately 20 minutes to the Umbrella Creek Hatchery for holding, genetic sampling, and spawning.

Pending results of ongoing and proposed research, an abundance-dependent release strategy that minimizes risks may be implemented. Lake stock will be used exclusively for lake plants. Investigations of the limiting factors affecting egg survival among different incubation sub-habitats, beach spawner abundance, productivity, and spatial distribution of the spawning habitat utilized, and genetic analysis of spawners at each beach spawning location; will precede future supplementation and/or reintroduction efforts on the beaches.

Any future outplants to unused beaches will be abundance based. On lower production years, only supplementation of existing spawning aggregations would be proposed. We propose a stepped experimental approach for considering future lake plants, including Olsen's and Allen's Beaches. This strategy will use population abundance to determine the number released, whether releases will be conducted on other beaches (pending research results and consensus), and the threshold below which no higher risk strategies will occur. For the purposes of this abundance-dependent strategy, adult abundance will be categorized as high, intermediate, or low, based the adult run size observed at the weir in the Ozette River and associated population estimates. High, intermediate, and low abundance years are identified as follows for the purposes of determining a release strategy:

High abundance equates to a count of >1,250 fish through the Ozette weir.
Intermediate abundance is defined by a count of 800 to 1,200 fish through the weir.
Low abundance is characterized by a count of less than 800 fish through weir.

Progeny will be allocated to the following supplementation strategies when abundance is high:
1. 60% of eyed eggs will be allocated for reintroduction onto appropriate new lake beaches.
2. 40% of eyed eggs will be allocated for supplementation on the source beach.

Progeny will be allocated to the following strategies when abundance is intermediate:
1. 40% of eyed eggs will be allocated for reintroduction onto appropriate new lake beaches.
2. 60% of eyed eggs will be allocated for supplementation on the source beach.

Progeny will be allocated to the following supplementation strategies when abundance is low:
1. 100% will be used to supplement the source beach.